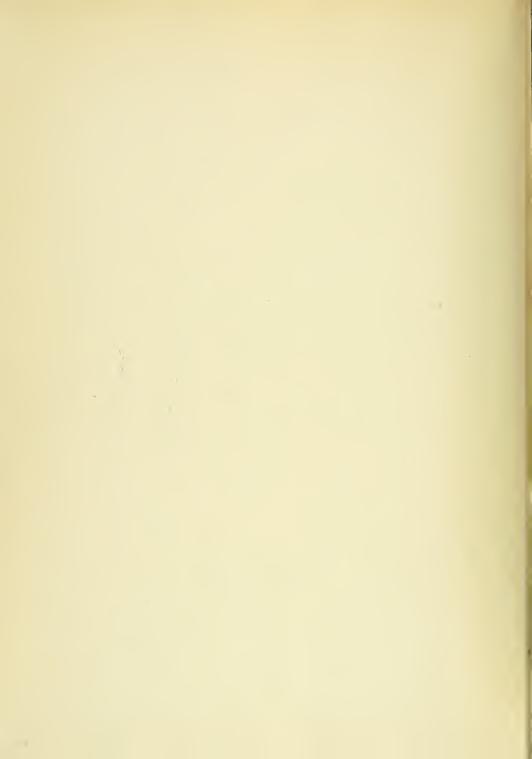


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VATURAL HISTORY



Exxon representative takes Newark high school students on a guided tour of facilities at Exxon's Bayway Refinery.

In 10 years, these high school students may help America overcome a major new shortage.

The 1980's. You'd expect them to be years of tremendous technological growth. But they may not be. Because by 1980, the U.S.

may face a severe shortage of scientists and engineers—even though we have the talent to prevent such a shortage.

The problem, however, is that much of this talent sits underdeveloped in the classrooms of our urban areas, especially where minorities comprise a major segment of the student body. And yet, this is where new technology could have its greatest impact—both on solving urban problems that need urgent answers—and in helping minority students gain new opportunities for careers in the upper levels of industry.

Unfortunately, many students with aptitudes for successful careers in science or engineering don't recognize their potential. Or if they do, their schools often lack the academic facilities to prepare them for university science curriculums. Exxon is trying to

change this situation in several ways.

For example, in cooperation with the National Science Foundation, Exxon recently

funded an innovative summer engineering program for high school students in the Newark, N.J. area.

During the six-week program, conducted at the Newark College of Engineering, the students held classroom chalk-talks; went on fact-finding field trips; analyzed the data on a computer and formulated theoretical engineering solutions to problems facing Newark today. These included problems in transportation, recreation, housing, sanitation and pollution.

While it's impossible to say how many of these students will eventually pursue careers in science and engineering, it's a fact that they all expressed more interest in these fields after the program. Next summer Exxon will be back in Newark. Until then, we'll continue our other programs to aid and promote engineering.

We'll again be working with the National Academy of Engineering to identify the critical factors limiting the enrollment and retention of minority students in engineering. We'll also be funding new engineering programs for minorities at 15 major colleges and universities—and helping to strengthen the engineering programs at predominately minority schools, such as Howard University, North Carolina A&T, Tuskegee Institute, Prairie View A&M, Tennessee State University and Southern University.

If we can help it, engineers and scientists are one shortage this country isn't going to have. We believe giving minority students equal opportunities in these fields is the way to prevent it.



NATURAL HISTORY

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Authors

Named by Time magazine as one of 200 rising American leaders, Carl Sagan is director of the Laboratory for Planetary Studies and professor of astronomy at Cornell University. Planetary atmospheres, space vehicle exploration of the planets, and the origin of life on earth are his principal research activities, but he is also known for his search for extraterrestrial life and intelligence and was responsible for placing an interstellar message aboard Pioneer 10, the first spacecraft to leave the solar system. Sagan received a Ph.D. in astronomy and astrophysics from the University of Chicago. He has published several hundred scientific papers and articles and written or edited more than a dozen books.



A doctoral candidate in the fields of fine arts and African studies at Indiana University, Lisa Aronson is particularly interested in African weaving and dyeing and its related crafts. As a start in sorting out the history of African textiles, Aronson spent the summer of 1973 analyzing and photographing collections of cloth brought from Africa in the eighteenth, nineteenth, and early twentieth centuries and now in ethnographic museums in England, Scotland, and France.



Michael E. Moseley's interest in the tightly knit social organization responsible for the construction of Chan Chan and the Huaca del Sol dates from 1967. when he first visited these monumental sites on the bleak Peruvian coast. Then a graduate student in anthropology, Moseley now teaches archeology at Harvard University and also directs the large archeological team that has been excavating these two complexes for the past five years. By the time the project is completed, Moseley hopes to have learned the economic, social, and ecological conditions that contributed to the rise and fall of the culture that erected these imposing complexes.

An allergy to mountain lions, kept Pamela McMahan from studying their behavior for her doctoral dissertation at the University of California at Davis. Attracted to predators because of their high intelligence and behavioral complexity, she switched to coyotes after an inquisitive pair followed her and won her affection in Big Bend National Park in west Texas. In connection with her research, McMahan has hand raised four coyotes, which she will attempt to return to the wild. She is currently beginning studies of the grasshopper mouse (the only predatory mouse species) and its insect prey.





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In the hope of evolving environmentally sound planning policies for the development of Lake Tahoe, the Tahoe Research Group is making intensive, longterm biological surveys of the area. Charles R. Goldman, director of the project, is professor of limnology in the Division of Environmental Studies at the University of California at Davis. Other project members, all associated with the Davis campus, are: David W. Deamer, associate professor of zoology, whose specialty is cell biology; Robert L. Leonard, group research director, who has been investigating the



influence of land disturbance on water quality; and limnologist Hans W. Paerl, whose work includes microscopic studies of plankton and detritus.



"The natural history of animals, and studying them in the field, has become my main interest and a way of life," writes London-born Katherine M. Homewood. A physical anthropologist, she was steered toward the Tana mangabey of Kenya, a rare and little-known primate, by the late Louis B. Leakey. After two years of field research, Homewood is completing her doctorate on the socioecology of this species at University College, London. Her next project will investigate the possibility of recolonizing patches of the Tana River forest, where the mangabey is locally extinct, as a test case for the general efficacy of captive breeding and restocking of endangered wildlife.

J. Gustave Speth is an attorney on the staff of the Natural Resources Defense Council, Inc., a national public interest law group involved exclusively in environmental litigation and public education. For the past few years he has concerned himself with the problems of nuclear power. He was the attorney for the Scientists' Institute for Public Information in a 1973 suit against the Atomic Energy Commission, which required the AEC to prepare an environmental impact statement for its fast breeder reactor development program. Speth is a former Rhodes Scholar and was law clerk to the late Hugo L. Black.



During Europe's dark ages the intrepid Norsemen pushed out with their dragon prowed ships into dark and uncharted seas. Their remains have been found as far east as Russia, as far south as Africa and there is strong evidence that they reached North America long before Columbus.

We know for certain they reached and settled in Iceland in the year 874. Accordingly this year Icelanders celebrate their 1100th anniversary.

It is fitting therefore that the Central Bank of Iceland should have chosen to mark the event with a special limited issue of sterling silver coinage.

The issue has been struck by the British Rayal Mint in proof quality to a standard of .925 pure silver. The dies have been specially polished and the blanks struck with extra firm pressure to show the designs to best advantage. **A Bull, a Bird, a Dragon,**

In Icelandic mythology the country has four guardian spirits; a bull, a bird, a dragon and a giant. They protect the land from

a Giant

invaders. Now, these protective spirits have been woven into a beautiful design to form the common reverse of both coins in this limited Icelandic anniversary issue.

The coins themselves

They are two in number and in the denominations of 500 and 1000 kronur. They depict two of Iceland's traditional legends.

The 500 kronur coin is 35 mm in diameter and weighs 20 grams. The obverse depicts a woman leading a two year old heifer. By tradition, the distance she could

cover between
dawn and
sunset was the
boundary of
her land.

The 1000 kronur coin is

39 mm in diameter and weighs 30 grams. The obverse depicts two settlers staking their land claim. A man lit a fire at sunrise, walked all day and lit another at sunset. The distance between the twa fires marked the boundaries of his territory.

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But today, after 10 years of intensive research, the Loup/Bétourné of Limoges, France (world's finest and largest Classic Enamelers) has perfected and patented the process that opens this whole new world of classic enamelling beauty!

Here are a few reasons why the Loup/Bétourné Studio succeeded where others had failed:

- A special enamel that would not crack or deform on the concave surface when fired was the key to success. Jean Bétourné invented such an enamel.
- To suppress deformities in the enamelling plaques during firing, a custom setting was designed for the Loup/Bétourné enamelling oven (the world's largest).
- 40 enamelers (including 4 Master Enamelers) will work night and day for six months to produce an Edition of only 300.
- A total of 15 to 18 days of work will be required for each plate.
- 50 seperate firings with temperatures varying between 1112 and 1832 degrees (depending on the color and chemical mixture employed) will be necessary for each plate.
- Uncounted hours will be spent preparing, hand-shaping and finally framing each plaque.

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As if the unequalled beauty of "Winter Scene" weren't enough, it's investment potential is excellent also! When you consider that works of art are today's best investment and that this is the first successful work in a new medium—you get a hint of the investment potential. But the most important factor to consider is that each of these Classic Enamelings will be done free hand—no stencil will be used. No two will be exactly alike . . . each "Winter Scene" will be an original work of art!

You will never again be able to buy a work of this type at the low price of \$750.00. Now that their concave copper enamelling technique has been perfected, Loup/Bétourné Studio will of course produce different editions. But with the way costs continue to rise, the last few "Winter Scene" enamellings will cost the studio almost double \$750.00! So the price tags on future editions will have to be \$1,000, \$2,000 or even \$3,000! It's just economic necessity.

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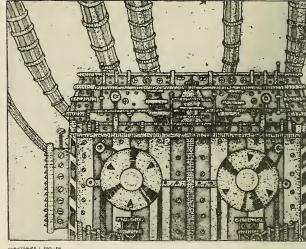
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In Praise of Robots

by Carl Sagan



CHRISTOPHER J. SPOLLEN

Human survival may depend on machines of high artificial intelligence

The word "robot," first introduced in the 1920s by the Czech writer Karel Capek, is derived from the Slavic root for "worker." But it signifies a machine rather than a human worker. Robots, especially robots in space, have lately been getting a bad press. We have read that a human being was necessary to make the terminal landing adjustments on Apollo 11, without which the first manned lunar landing would have ended in disaster; that a mobile robot on the lunar surface could never have been so clever as the astronauts in selecting samples to be returned to earthbound geologists; and that machines could never have repaired, as men did, the sunshade that was so vital for the continuance of the Skylab missions.

All these comments turn out, naturally enough, to have been written by humans. I wonder if a small self-congratulatory element, a whiff of human chauvinism, has not crept into these judgments. Just as whites can sometimes detect racism and men can occasionally discern sexism, I wonder whether we cannot here glimpse some comparable affliction of the human spirit-a disease that as yet has no name. The word "humanism" has been preempted by other and more benign activities of mankind. From the analogy with sexism and racism I suppose the name for this malady could be "speciesism"-the prejudice that there are no beings so fine, so capable, and so reliable as human beings.

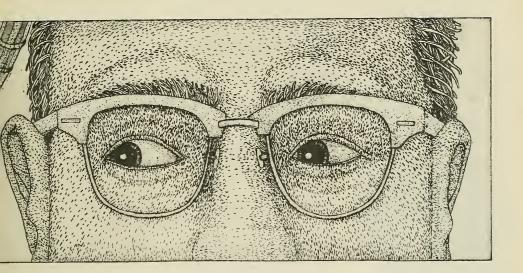
This is a prejudice because it is, at the very least, a prejudgment-a conclusion drawn before all the facts are in. Such comparisons of men and machines in space are comparisons of smart men with dumb machines. We have not asked what sorts of machines could have been built for the thirty or so billion dollars that the Apollo and Skylab missions together cost.

Each human being is a superbly constructed, astonishingly compact, self-ambulatory computer-capable on occasion of independent decision making and real control of his or her environment. But there are serious limitations to employing human beings in certain environments. For example, without a great deal of protection, human beings would be inconvenienced on the

ocean floor, the surface of Venus, the deep interior of Jupiter, or even on long space missions. Perhaps the only interesting information from Skylab that could not have been obtained by machines is that when human beings remain in space for a period of months, they undergo a spectacular loss of bone calcium and phosphorus. This seems to imply that human beings will be incapacitated under zero gravity on missions of six to nine months or more. The minimum interplanetary voyages have characteristic lengths of a year or two. Spinning the spacecraft can produce a kind of artificial gravity, but it is inconvenient and costly.

Because we value human beings highly, we are reluctant to send them on extremely risky missions. If we do send human beings to exotic environments, we must also send along their food, their air, their water, amenities for entertainment and waste recycling, and companions. Machines, however, need no elaborate lifesupport systems, no entertainment, no companionship, and we do not yet feel strong ethical prohibitions against sending them on one-way or suicide missions.

Certainly for simple missions, machines have proved themselves



many times over. Unmanned vehicles performed the first photography of the whole earth and the far side of the moon, the first landings on the moon and Venus, and in the Mariner 9 mission to Mars, the first thorough reconnaissance of another planet. Here on earth it is increasingly common for high-technology manufacturing-in chemical and pharmaceutical plants, for exampleto be performed largely or entirely under computer control. In all these activities machines are able, to some extent, to sense errors, correct mistakes, and alert distant human controllers about perceived problems. The powerful arithmetical abilities of computing machines-now hundreds of millions of times faster than unaided human beings-is legendary. But what about really complex discussions? Can machines, in any sense, think through a new problem? Can they make discussions of the branched-contingency-tree variety, which we think of as characteristically human? (That is, I ask question 1; if the answer is A, I ask question 2; if the answer is B, I ask question 3; and so on.)

Some decades ago the English mathematician Alan Mathison Turing described what would be necessary for him to believe in machine intelligence. The condition was simply that he could be in teletype or typewriter communication with a machine and be unable to tell that it was not a human being. Turing imagined the following conversation between a man and a machine:

Q. In the first line of your sonnet, which reads "Shall I compare thee to a summer's day," would not "a spring day" do as well or better?

A. It wouldn't scan.

Q. How about "a winter's day"? That would scan all right.

A. Yes, but nobody wants to be compared to a winter's day.
 Q. Would you say Mr. Pickwick

reminded you of Christmas?

A. In a way.

Q. Yet Christmas is a winter's day, and I do not think Mr. Pickwick would mind the comparison. A. I don't think you're serious. By a winter's day one means a typical winter's day, rather than a special one like Christmas.

No machine of this sophistication has yet been built, but so far only a limited amount of effort and money has been put into artificial intelligence, and there are only a half-dozen centers of such activity in the world. One of the more striking results, obtained in a very limited universe of discourse—that of children's blocks comes from work done at the Artificial Intelligence Laboratory of the Massachusetts Institute of Technology. Here is a dialogue between a man and a machine:

Man. What does the box contain? Machine. The blue pyramid and the blue box.

Man. How many blocks are not in the box?

Machine. Four of them.

Man. Is at least one of them narrower than the one that I told you to pick up?

Machine. Yes, the red cube. Man. Is there a steeple?

Machine. Sorry, I don't know the word "steeple."

Man. A steeple is a stack that contains two green cubes and a pyramid, for example.

Machine. I understand.

Man. Are there any steeples now?

Machine. No. Man. Build one.

The machine does. It reaches out its mechanical hand, moves the cubes, and builds the structure that has just been described.

Man. When did you pick up the pyramid?

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Machine. While I was stacking up the red cube, the large red block, and the large green cube. Man. Why?

Machine. To get rid of it.

Man. Why did you clear off that cube?

Machine. To put it on the large green cube.

As another example, a computer program that imitates a psychiatrist was also once developed at MIT. This is a much simpler program than the blocks program because it does not attempt to "understand" much of what is said to it, but only manipulates the phrases in sentences it has heard in accordance with a contingency tree sensitive to certain words that are considered especially important by humans. This program involves nondirective psychotherapy, which generally speaking, requires extremely simple computer programs. Here is a remarkable dialogue between a human being and a computer psychotherapist. (It is one of the most interesting of such conversations. Many other such machine/human psychiatric dialogues are not nearly so striking. But I suppose most human/ human psychiatric dialogues are not very striking either.) In order to keep the respective roles of therapist and patient clear in this interaction, the computer therapist types upper case while the patient types lower case:

men are all alike.
IN WHAT WAY?

they're always bugging us about something or other.

CAN YOU THINK OF A SPECIFIC EXAMPLE?

well, my boyfriend made me come here.

YOUR BOYFRIEND MADE YOU COME HERE?

he noticed that i'm depressed much of the time.

I AM SORRY TO HEAR YOU ARE DEPRESSED.

he's right. i am unhappy.

DO YOU THINK COMING HERE WILL HELP YOU NOT TO BE UNHAPPY?

i need some help, that much is clear.

WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP? perhaps i could learn to get

along with my mother.
TELL ME MORE ABOUT YOUR FAM-

my mother takes care of me.
WHO ELSE IN YOUR FAMILY TAKES
CARE OF YOU?
my father.

YOUR FATHER?
you are like my father in some
ways

WHAT RESEMBLANCE DO YOU SEE? you are not very aggressive, but i don't think you want me to notice that.

WHAT MAKES YOU THINK I AM NOT VERY AGGRESSIVE?

you don't argue with me.
WHY DO YOU THINK I DON'T ARGUE
WITH YOU?

you are afraid of me.

DOES IT PLEASE YOU TO BELIEVE I AM AFRAID OF YOU?

it pleases my father to think i am afraid of him.

WHAT ELSE COMES TO MIND WHEN YOU THINK OF YOUR FATHER? bullies.

DOES THAT HAVE ANYTHING TO DO WITH THE FACT THAT YOUR BOYFRIEND MADE YOU COME HERE?

This astonishing—one is very tempted to say perceptive-response from the computer is, of course, preprogrammed. But then, so are the responses of human psychotherapists. No such computer program is adequate for psychiatric use today, but the same can be remarked about some human psychotherapists. In a period when more and more people in our society seem to be in need of psychiatric counseling, and when time sharing of computers is widespread, I can imagine the development of a network of computer psychotherapeutic terminals, something like arrays of large telephone booths, in which, for a few dollars a session, we would be able to talk with an attentive, tested, and largely nondirective psychotherapist. Insuring the confidentiality of the psychiatric dialogue is probably the most important step to be worked out.

Another sign of the intellectual accomplishments of machines is found in games. Even exceptionally simple computers—those that can be wired by a bright tenyear-old—can be programmed to play perfect tic-tac-toe. One computer has played master-class

checkers—it has beaten the Connecticut state champion. Chess is a much more difficult game than tic-tac-toe or checkers. Here, programming a machine to win is not easy, and novel strategies have been used, including several successful attempts to have a computer learn from its own experience in playing previous chess games. For example, computers can learn empirically that it is better in the beginning game to control the center of the chess board than the periphery.

So far no computer has become a chess master; the ten best chess players in the world have nothing to fear from any present machine. But several computers have played well enough to be ranked somewhere in the middle range of serious, tournamentplaying chess players. I have heard machines demeaned (often with a just audible sigh of relief) because chess is an area in which human beings are still superior. This reminds me of the old joke in which a stranger remarks with wonder on the accomplishments of a checker-playing dog, whose owner replies, "Oh it's not all that remarkable. He loses two games out of three." A machine that plays chess in the middle range of human expertise is a very capable machine; even if there are thousands of better human-chess players, there are millions of worse ones. To play chess requires a great deal of strategy and foresight, analytical powers, the ability to cross-correlate large numbers of variables and to learn from experience. These are excellent qualities not only for individuals whose job it is to discover and explore but also for those who watch the baby and walk the dog.

Chess-playing computers, because they have very complex programs, and because, to some extent, they learn from experience, are sometimes unpredictable. Occasionally they perform in a way that their programmers would never have anticipated. Some philosophers have argued for free will in human beings on the basis of our sometimes unpredictable behavior. But the case of the chess-playing computer clearly tells us that, when viewed from the outside, behav-

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ior may be unpredictable only because it is the result of a complex although entirely determined set of steps on the inside. Among its many other uses, machine intelligence can help illuminate the ancient philosophical debate on free will and determinism.

With this more or less representative set of examples of the state of development of machine intelligence, I think it is clear that a major effort over the next decade, involving substantial investments of money, could produce much more sophisticated programs. I hope that the inventors of such machines and programs will become generally recognized as the consummate artists they are.

In thinking about the next generation of machine intelligence, it is important to distinguish between self-controlled and remotely controlled robots. A selfcontrolled robot has its intelligence within itself; a remotely controlled robot has its intelligence located someplace else, and its successful operation depends upon successful communication between its external central computer and itself. There are, of course, intermediate cases in which the machine may be partly self-activated and partly remotely controlled. The mix of remote and in situ control seems to offer the highest efficiency for the near

We can imagine, for example, such a machine designed for the mining of the ocean floor. Enormous quantities of manganese nodules litter the abyssal depths. They were once thought to have been produced by meteorite infall on the earth, but are now believed to be formed occasionally in vast manganese fountains caused by the internal tectonic activity of the earth. Many other scarce and industrially valuable minerals are likewise to be found on the deep ocean bottoms. We clearly have the capability today to design devices that can systematically swim above or crawl upon the ocean floor, perform spectrometric and other chemical examinations of the surface material, radio back all findings to ship or land, and by means of low-frequency radio homing instruments, mark the sites of especially valuable deposits.

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The radio beacon in the robot will then direct great mining machines to the appropriate locales. The present state of the art in deep-sea submersibles and in spacecraft environmental sensors is compatible with the development of such devices. A similar situation exists for offshore oil drilling, for coal and other mineral mining, and other operations. The likely economic returns from such devices would pay not only for their development but for the entire future space program many times over at the present rate of spending.

Machines can be programmed to recognize particularly difficult situations and to inquire of human operators-working in safe and pleasant environments-what to do next. The examples just given are of devices that are largely self-controlled. Remotely controlled devices are also possible, and a great deal of preliminary work has been done in the remote handling of highly radioactive materials in laboratories of the U.S. Atomic Energy Commission. In the application of this technology, I can imagine a human operator connected by radio link with a mobile machine; for example, the operator is in Manila; the machine is in the Mindanao trench in the Philippine Sea-the deepest level of the earth's surface. The operator is attached to an array of electronic relays that transmit and amplify his movements to the machine and that can, conversely, carry back to his senses what the machine perceives. When the operator turns his head to the left, the television cameras on the machine will turn left, and the operator will see on a great hemispherical television screen the scene revealed by the machine's searchlights and cameras. When the operator in Manila takes a few steps forward, the machine in the abyssal depths will amble a few meters forward; when the operator reaches out his hand, the mechanical arm of the machine will extend itself. The precision of the man-machine interaction will be such that exact manipulation of material on the ocean bottom by the machine's fingers will be possible. With such devices, human beings will be able to "enter" environments otherwise closed to them forever.

In the exploration of Mars, the time is almost upon us when unmanned vehicles will soft land; only a little further in the future they will roam about the surface of the red planet as some do now on the moon. We are not yet ready for a manned mission to Mars. (Some of us are concerned about such missions because of the danger of carrying terrestrial microbes to Mars and Martian microbes, if they exist, back to earth; and because of the enormous expense involved.)

The unmanned Viking landers scheduled to be deposited on Mars in the summer of 1976, however, have a very interesting array of sensors and scientific instruments. Each lander has two cameras with the resolution and stereoscopic capabilities of the human eye, plus a much greater range of color sensitivity, extending into the near infrared. Each lander has a single ear-a seismometer sensitive only to the lowest frequencies in the audio spectrum. The seismometer is, in fact, equipped with a filter to prevent higher frequencies from being registered. Viking also has an elaborate instrument that is the equivalent of a nose and taste buds. This gas chromatograph/mass spectrometer will enable the landers to detect, in abundances of parts per million, hundreds of different organic molecules, many of which unaided humans are incapable of detecting. The Viking lander sports a single arm with which to collect the Martian soil and withdraw it into its body for further examination. Among the lander's range of instruments are three biology sensors, unknown to human anatomy, that are designed to measure microbial metabolism. (However, were we to ingest soil samples, as Viking will, and were those samples to contain microbes, we might discover them by getting sick.) Although it will have the capacity to taste, Viking will not have to eat while on the Martian surface. The lander is equipped with two radioactive thermal generators, which will generate electricity from the radioactive decay of the element plutonium. This is an

energy source that should be adequate for a lifetime of many months on the Martian surface.

(The reprogrammability of computers is an important virtue. Suppose we send a human astronaut to Mars, trained in, say, geology. After he or she lands, we discover that we really should have sent a biologist. Reprogramming the astronaut is equivalent to waiting for that individual to complete, on Mars, a remote postgraduate course in biology. A robot geologist on Mars, however, would require only a few hours to be reprogrammed and debugged for biology.)

The obvious post-Viking approach to Martian exploration, one that takes advantage of the Viking technology, would be a tractor-treaded robot rover that would carry the entire Viking spacecraft slowly over the Martian landscape. But such a vehicle would pose a new problem, one never encountered in machine operation on the earth's surface. Although Mars is the second closest planet to Earth, it is so far away that the light travel time between the two becomes significant. At a typical relative position of Mars and Earth, the red planet is twenty light minutes away. A message from the robot on Mars to the human controller on Earth, traveling at the speed of light, would take twenty minutes to arrive. Thus, if the spacecraft encountered a steep incline, it might send a message of inquiry back to the earth. Forty minutes later the response would arrive, saying something like, "For heaven's sake, stand dead still." By then, of course, an unsophisticated machine would have tumbled into the gully. Any Martian rover consequently requires slope and roughness sensors. Fortunately these are readily available and are even found on some children's toys. When confronted with a steep slope or boulder, a rover so equipped would either stop until it received instructions from the earth in response to its query (sent with a televised picture of the terrain) or back away and move in another and safer direction. If every decision in Martian exploration must be fed through a human controller on

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the earth, the robot rover can traverse only a few feet an hour. But the lifetimes of such roversand of human operators-are so long that a few feet an hour represents a perfectly respectable rate of progress.

Contingency decision networks much more elaborate than anything now in existence can be built into the onboard computers of spacecraft of the 1980s. For objectives more remote than Mars, to be explored further in the future, we can imagine human controllers in orbit nearby. In the exploration of Jupiter, for example, I can envisage operatorsinstalled on a small moon outside the planet's fierce radiation beltscontrolling, with only a few seconds' delay, the responses of a spacecraft floating in the dense Jovian clouds or wandering about its metallic hydrogen oceans. Earthbound human beings can also be part of such an interaction loop, provided they have the patience to cope with the increased light travel time involved. As we speculate about expeditions into the farthest reaches of the solar system-and ultimately to the stars-self-controlled machine intelligence will clearly assume heavier burdens of responsibility.

In the development of such machines we find a kind of convergent evolution. The Viking lander is, in a curious sense, like some great, outsize, clumsily constructed insect. It is not yet ambulatory, and it is certainly incapable of self-reproduction. But it has an exoskeleton, a wide range of insectlike sensory organs, and is about as intelligent as a dragonfly. Viking also has an advantage that insects do not; by inquiring of its controllers on earth, it can, in effect, assume the intelligence of a human beingthat is, its controllers are able to reprogram the Viking computer on the basis of decisions that

they make.

To construct something with the intelligence of an insect may not seem a very impressive feat. But it is a feat that took nature four billion years to accomplish. We have been exploring space for less than a hundred-millionth of that time. A machine of this intelligence is a great human achievement.

As the field of machine intelligence advances and as more and more distant objects in the solar system become accessible to exploration, we will see the development of increasingly sophisticated onboard computersinstruments that slowly climb the phylogenetic tree from insect intelligence to crocodile intelligence to squirrel intelligence and, in the not very remote future, I think, to dog intelligence. Any flight to very great distances must have a computer capable of determining whether it is working properly. There will be no possibility of sending to earth for a repairman. The machine must be able to sense it is sick and skillfully doctor its own illnesses. A computer is needed that is able either to fix or replace its own failed parts or sensors or structural components. Such a computer, which has been called STAR-for Self-Testing And Repairing computer-is on the threshold of development. It employs redundant components, as biology does-we have two lungs and two kidneys partly because each is protection against failure of the other. But a computer can be much more redundant than a human being-we have, after all, only one head and one heart.

In view of the weight premium on deep-space exploratory ventures, there will be strong pressures for continued miniaturization of intelligent machines. Remarkable miniaturization has already occurred; vacuum tubes have been replaced by transistors and wired circuits by printed circuit boards. A few years ago a circuit that occupied much of a 1930s radio set was regularly being printed on the equivalent of the head of a pin. Today the same circuit can be printed on the point of a pin, and the head can accommodate a fair fraction of a small computer.

If intelligent machines for terrestrial mining and space exploratory applications are pursued, the time is not far off when household and other domestic robots will become commercially feasible. Unlike the classical anthropoid robots of science fiction, there is no reason for such machines to look any more human than a vacuum cleaner does. They will be specialized for their



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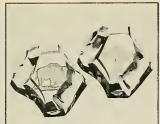
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functions. There are many common tasks, ranging from bar tending to floor washing, that involve a limited array of intellectual capabilities, although they require substantial stamina and patience. All-purpose ambulatory household robots, capable of performing the domestic functions of a proper nineteenthecentury British butler, are probably many decades off. But more specialized machines, adapted to specific household functions, are already on the horizon.

Conceivably, many other civic tasks and essential functions of everyday life could also be carried out by intelligent machines. A recent newspaper report states that garbage collectors in Anchorage, Alaska, have won a wage settlement guaranteeing them a yearly salary of \$18,000. Economic pressures alone may make a persuasive case for the development of automated garbage-collecting machines. For the development of domestic and civic robots to be a general social good, the effective reemployment of those displaced by robots must, of course, be arranged; but over a human generation that should not be too difficult-particularly if enlightened educational reforms are initiated.

We appear to be on the verge of developing a wide variety of intelligent machines capable of performing tasks too dangerous, too expensive, too onerous, or too boring for human beings. The development of these machines is, in my mind, one of the few legitimate spin-offs of the space program. The main obstacle to their development seems to be a human problem: the quiet feeling that comes stealthily and unbidden to claim that there is something unpleasant or "inhuman" about machines performing certain tasks as well as, or better than, humans; the feeling that generates a sense of loathing for creatures made of silicon and germanium rather than proteins and nucleic acids.

Our survival as a species depends on our transcending these primitive chauvinisms. Adjustment to intelligent machines is, in part, a matter of acclimatization. There are cardiac pacemakers in existence that sense the

beat of the human heart. Only at the slightest hint of fibrillation does the pacemaker stimulate the heart. This is a mild but useful sort of machine intelligence. I cannot imagine the wearer of this device resenting its intelligence. I think that there will shortly be a similar sort of acceptance for much more intelligent and sophisticated machines. We have a generation of youngsters who are growing up with pocket computers, machine languages, computer graphics, electronic music, automated instruction, and computer games. They are unlikely to find anything alien about machine intelligence. There is nothing inhuman about an intelligent machine; it is, indeed, the expression of those superb intellectual capabilities that only human beings, of all the creatures on our planet, now possess.

A legitimate concern in the development of machine intelligence is its potential for misuse by unscrupulous governmental, military, and police agencies. Here, as in many other areas of modern technology, the same devices can be used either for enormous good or enormous evil. A world with central data banks containing dossiers on all its citizens, with robot policemen and robot judges, and with automated battlefields is not a world in which I personally would care to live and bring up children. It would be a nightmare world. But a world with adequate food, mineral, and energy resources; a world that provides its human inhabitants with ample leisure and an intellectually and spiritually rich environment with which to make that leisure meaningful; a world engaged in the exploration of other distant and exotic worlds-that is a world I would find extremely attractive. Both of these future worlds are accessible through machine intelligence. To avoid the nightmare and realize the dream requires a wholesale restructuring of the planet's political institutions—a restructuring that is clearly required quite apart from the implications of intelligent machines. If we survive, I think our future will depend to a significant degree on a partnership between human and machine intelligence.

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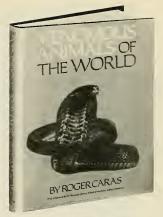
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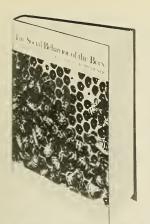
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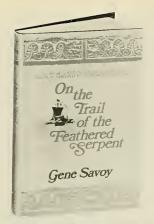
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Evolution and the Brain

Carnivores—and primates need larger brains than plant eaters to survive

Nature discloses the secrets of her past with the greatest reluctance. We paleontologists weave our tales from fossil fragments poorly preserved in incomplete sequences of sedimentary rocks. Most fossil mammals are known only from teeth—the hardiest substance in our bodies—and a few scattered bones. A famous paleontologist once remarked that most of mammalian history involved only the mating of teeth to produce slightly modified descendant teeth.

We rejoice at the rare preservation of soft parts-mammoths frozen in ice or insect wings preserved as carbonized films on beds of shale. Yet most of our information about the soft anatomy of fossils comes, not from these rare accidents, but from evidence commonly preserved in bone-the insertion scars of muscles or the holes through which nerves pass. Fortunately, the brain has also left its imprint upon the bones that enclose it. When a vertebrate dies, its brain quickly decays, but the resultant hole in the skull may be filled by sediment that hardens to produce a natural cast. This cast can preserve nothing of the brain's internal structure, but its size and external surface may faithfully copy the original.

Unfortunately, we cannot simply measure the volume of a fossil cast to obtain a reliable measure of an animal's intelligence; paleontology is never that easy. We must consider two problems.

First, what does brain size mean? Does it correlate at all with intelligence? There is no evidence for any relationship between intelligence and the normal range of variability for brain size within a species (fully func-

tional human brains range from less than 1,000 to more than 2,000 cubic centimeters in volume). The variation of individuals within a species, however, is not the same phenomenon as variation in average values for different species. We must assume that, for example, average differences in brain size between humans and tuna fish bear some relationship to a meaningful concept of intelligence. Besides, what else can paleontologists do? We must work with what we have, and brain size is most of what we

Secondly, the primary determinant of brain size is not mental capacity, but body size. A large brain may reflect nothing more than the needs of the large body that housed it. Moreover, as I argued in last February's column, the relationship of brain size to body size is not a simple one. As animals get larger, brains increase in size at a slower rate. The brains of small animals are relatively large; that is, the ratio of their brain weight to body weight is higher. We must find some way to remove the influence of body size. This is done by plotting an equation for the "normal" relationship between brain weight and body weight.

Suppose we are studying mammals. We compile a list of average brain and body weights for adults of as many different species as we can. These species form the points of our graph; the equation that fits these points indicates that brain weight increases about two-thirds as fast as body weight. We can then compare the brain weight of any given species with the brain weight for an "average" mammal of that body weight. This comparison removes the influence of body size. A chimpanzee, for example, has an average brain weight of 395 grams. An average mammal of the same body weight should have a brain weight of 152 grams according to our equation. A chimp's brain is, therefore, 2.6 times as heavy as it "should" be (395/152). We may refer to this ratio of actual to expected brain size as an "encephalization quotient"; values greater than 1 signify larger than average brains; values less than 1 mark smaller than average brains.

But this method imposes another difficulty on paleontologists. We must now estimate body weight as well as brain weight. Complete skeletons are very rare and estimates are often made from a few major bones alone. To pile difficulty upon difficulty, only birds and mammals have brains that completely fill their cranial cavities. In these groups, a cranial cast faithfully reproduces the size and form of the brain. But in fishes, amphibians, and reptiles, the brain occupies only part of the cavity, so the fossilized cast is larger than the actual brain. We must estimate what part of the cast the brain would have occupied in life. And yet, despite this plethora of difficulties, assumptions, and estimates, we have been able to establish, and even to verify, a coherent and intriguing story about the evolution of brain size in vertebrates.

California psychologist Harry J. Jerison has recently marshaled all the evidence—much of it collected during his own labors of more than a decade—in a book entitled *The Evolution of the Brain and Intelligence* (New York, Academic Press, 1973).

Jerison's major theme is an attack upon the vulgar notion that vertebrate classes can be arranged in a ladder of perfection leading from fish to mammal through the intermediary levels of amphibian, reptile, and bird. Jerison prefers a functional view

that relates the amount of brain to specific requirements of modes of life, not to any preordained or intrinsic tendency for increase during the course of evolution. The potential "brain-body space" of modern vertebrates is filled in only two areas: one occupied by the warm-blooded vertebrates (birds and mammals), the other by their cold-blooded relatives (fish, amphibians, and modern reptiles). (Sharks provide the only exception to this general rule. Their brains are much too bigquite a surprise for these supposedly "primitive" fishes, but more on this later.) Warm-blooded vertebrates, to be sure, have larger brains than their cold-blooded relatives of the same body size, but there is no steady progress toward higher states, only a correlation between brain size and basic physiology. In fact, Jerison believes that mammals evolved their large brains to meet specific functional demands during their original existence as small creatures competing on the periphery of a world dominated by dinosaurs. He argues that the first mammals were nocturnal and that they needed larger brains to translate the perceptions of hearing and smell into spatial patterns that animals active in daylight could detect by vision alone.

Jerison provides his tidbits within this framework. I hate to confute a comfortable item of received dogma, but I must report that dinosaurs did not have small brains—they had brains of just the right size for reptiles of their immense dimensions. We should never have expected more from Brontosaurus because large animals have relatively small brains, and reptiles of any weight have smaller brains than mammals.

The gap between modern coldand warm-blooded vertebrates is neatly filled by intermediate fossil forms. Archaeopteryx, the first



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bird, is known from fewer than half a dozen specimens, but one of them has a well-preserved brain cast. This intermediate form with bird feathers and reptilian teeth had a brain that plots right in the middle of the unfilled area between modern reptiles and birds. The primitive mammals that evolved so rapidly after dinosaurs became extinct had brains intermediate in size between reptiles and modern mammals of corresponding body weights.

We can even begin to understand the mechanism of this evolutionary increase in brain size by tracing one of the feedback loops that inspired it. Jerison computed the encephalization quotients for carnivores and their putative prey among ungulate herbivores for four separate groups: "archaic" mammals of the early Tertiary (the Tertiary is the conventional "age of mammals" and represents the last 70 million years of earth history); advanced mammals of the early Tertiary; middle to late Tertiary mammals; and modern mammals. Remember that an encephalization quotient of 1.0 denotes the expected brain size of an average modern mammal.

	Herbi-	Carni-
	vores	vores
Early Tertiary		
(archaic)	0.18	0.44
Early Tertiary		
(advanced)	0.38	0.61
Middle to late		
Tertiary	0.63	0.76
Modern	0.95	1.10

Both herbivores and carnivores displayed continual increase in brain size during their evolution, but at each stage, the carnivores were always ahead. Animals that make a living by catching rapidly moving prey seem to need bigger brains than plant eaters. And, as the herbivores increased their brain size (presumably under the intense selective pressure of their carnivorous predators), the carnivores also evolved larger brains to maintain the differential.

South America provides a natural experiment to test this claim. Until the Isthmus of Panama rose just a couple of million years ago, South America was an isolated island continent. Advanced carnivores never reached this island, and predatory roles were filled by marsupial carnivores with low encephalization quotients. Here, the herbivores display no increase in brain size through time. Their average encephalization quotient remained below 0.5 throughout the Tertiary, and they were quickly eliminated when advanced carnivores crossed the isthmus from North America. Again, brain size is a functional adaptation to the ways animals make a living, not a quantity with an inherent tendency to increase. When we document an increase, we can relate it to specific requirements of ecological roles. Thus, we should not be surprised because sharks have such large brains; they are, after all, the top carnivores of the sea, and brain size reflects mode of life, not time of evolutionary origin. Likewise, carnivorous dinosaurs like Allosaurus and Tyrannosaurus had larger brains than herbivores like Brontosaurus.

But what about our preoccupation with ourselves; does anything about the over-all history of vertebrates indicate why one peculiar species should be so brainy? Here's a closing item for thought. The most ancient brain cast of a mammal in our order of primates belongs to a 55-millionyear-old creature named Tetonius homunculus. Jerison has calculated its encephalization quotient at 0.68. This is, to be sure, only two-thirds the size of just an average living mammal of the same body weight, but it is by far the largest brain of its time (making the usual correction for body weight), and it is more than three times as large as an average mammal of its period. Primates have been ahead right from the start; our large brain is only an exaggeration of a pattern set at the beginning of the age of mammals. But why did such a large brain evolve in a group of small, primitive, tree-dwelling mammals, more similar to rats and shrews than to mammals conventionally judged as more advanced? And with this provocative query, I end, for we simply do not know the answer to one of the most important questions we can ask.

Columnist Stephen Jay Gould teaches geology at Harvard University.

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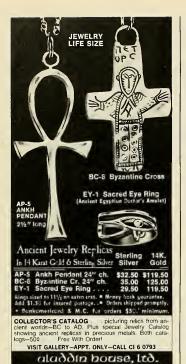
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Rotten Apples and Ripe Bananas

A component of the gas that can heat your house and run your stove also has a dramatic effect on fruits

There is truth in the folk saying that one rotten apple will spoil a whole barrelful of fruit. In recent years, plant tissue either mechanically injured or invaded by a fungus has been shown to produce large quantities of a simple, wellknown hydrocarbon gas-ethylene. This hydrocarbon occurs in the natural gas widely used as heating and cooking fuel. When supplied to healthy plant tissue, the gas produces some remarkable and drastic consequences. One of these is to stimulate the healthy tissue also to produce ethylene. Thus, one whiff of ethylene produces a cascade effect, and soon the entire barrel is full of ethylene-producing fruits. When the concentration of ethylene gets sufficiently high, the fruit tissue goes through the transformations we normally associate with ripening and rotting-softening, sweetening, darkening, and eventually, dissolution.

The adverse effects of ethylene on plant growth and development have been known for many years. In the 1920s an American grower of chrysanthemums had a greenhouse full of plants being readied for the market, when the weather turned cold. He decided to heat his greenhouse with a burner system operating on natural gas, a method he had previously used without mishap. This time, unfortunately, the burner system was not properly adjusted, and some of the uncombusted gas was released into the greenhouse. When the grower returned, he found that all of the plants had dropped their leaves. His crop was completely unmarketable. The economic loss was great enough to spur research into the identification of the toxic

agent. After a few years, it became clear that unsaturated hydrocarbons were responsible: common gases like ethylene, propylene, butylene, and acetylene were found to be effective defoliators, and ethylene was as active as any other compound. To protect plants from the deleterious effects of natural gas, it was sufficient to trap the ethylene and related gases by simple chemical techniques, such as bubbling the gas mixture into bromine water. That process works because two atoms of bromine add onto the ethylene molecule, converting it into nonvolatile ethylene dibromide. Saturated hydrocarbons, such as ethane, propane, and butane, do not undergo such an addition reaction with bromine and are accordingly swept away with the effluent gas stream. Gas deprived in this manner of its unsaturated components produces no harmful effects on plants.

What can be done with a barrel of apples that constantly produce their own ethylene? Continually sifting the barrel contents to remove an apple the moment it begins to look rotten is obviously impractical. It is also not economically practical to bubble the air in the barrel through bromine water at frequent intervals. A much simpler method is to add a compound that will counteract the effect of ethylene on the healthy apple tissue. Such a compound is another simple gas, carbon dioxide, produced by all living cells in the process of respiration. The normal concentration of carbon dioxide in the air is 0.03 percent of the total. At that low level, carbon dioxide is unable to counteract the effects of even small quantities of ethylene. But when the carbon dioxide concentration of a closed container is raised to 5 percent, even large doses of ethylene are effectively antagonized. Modern practice, therefore, is to store apples for long periods in cooled, sealed atmospheres containing about 5 percent carbon dioxide. While this method is obviously beneficial in reducing apple spoilage, it has also led to the deplorable custom of almost never selling a fresh apple. The older, stored fruit is sold first, while the newly harvested fruit is placed in high carbon dioxide storage. Hence a good, fresh eating apple is hard to find; the stored product, while not rotten, lacks the distinctive flavor and aroma of the fresh fruit.

Despite its generally deleterious effects, externally applied ethylene can sometimes be useful. If hard, starchy, unripe bananas are exposed briefly to minute concentrations of ethylene, they gradually turn into the soft, sweet, speckled, ripe yellow bananas of commerce. This information has been of great benefit to banana growers and shippers. If bananas are harvested when they are soft and ripe, shipment without serious bruising injury is practically impossible; by the time the fruit arrives at its destination, it will either be completely discolored and crushed or actually rotten. Transport of the fruit became much simpler after the discovery that bananas cut off the tree while still green will ripen when exposed to ethylene. Today's growers harvest the firm, unripe fruit and ship it to storage warehouses, where, treated with ethylene, it ripens within a few days. The ripe fruit is then transported to nearby markets without injury. Most of the bananas we eat these days are handled in this manner.

If ethylene causes the artificial ripening of bananas, is it also responsible for the natural ripening of the fruit? The answer is almost certainly yes. When gas samples are removed at various times from within the fruit tissue, simple chemical analysis shows that ethylene is present and rises to a sharp peak shortly before the onset of ripening. In many fruits, this normal development of a peak of ethylene in the tissue is followed

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Burleigh Brooks Optics, Inc. 44 Burlews Ct., Hackensack, N.J. 07601 by a tremendous elevation in the rate of carbon dioxide evolution. Such a peak of respiratory gas output in fruits is referred to as a climacteric. Following the climacteric, changes caused by enzymes within the fruit lead to the typical softening, sweetening, and color changes. Thus, we must conclude that natural fruit ripening is controlled by ethylene produced in the plant.

Ethylene is also partly responsible for the development of the abscission layer in stalks, which causes the shedding of leaves and fruits. The unlucky chrysanthemum grower who defoliated his plants with natural gas was therefore merely hastening a natural process. Similarly, a pineapple grower who induces his plants to flower by spraying them with a synthetic hormone-type compound is simply stimulating his plants to produce extra ethylene. The same effects on flower promotion can be achieved by ethylene alone.

Saturating an entire open pineapple field with ethylene gas is obviously impractical. Normal diffusion and wind-aided convection would quickly carry the gas out of range of the plants. For this reason, growers and scientists have searched for forms of ethylene that could be applied as liquids. In the late 1960s, it was discovered that a simple, water-soluble ethylene derivative, chloroethanephosphonic acid, could release ethylene inside plant cells. A commercial version. called Ethephon, when applied in an open pineapple field at the rate of one to four pounds per acre causes 100 percent flower induction. The sprayed fruits not only mature more rapidly than untreated controls but they also all mature simultaneously. Spraying consequently makes the pineapples more amenable to mechanical and other rationalized harvest techniques. Because of these benefits, this ethylene derivative has found wide acceptance in agriculture.

Where in the plant does eth-ylene come from? And why is it made at such restricted times in the plant's life cycle? Answers to these and related questions of importance to plant physiologists can only be given in tentative terms. Experiments using radioactively labeled materials show that ethylene is made from the amino acid

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methionine, which exists in all living cells and is a component of



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Hormones are usually defined as naturally occurring organic compounds, found in minute quantities in plants and animals, that produce great physiological effects when transported from their place of origin to the specific tissue on which they act. Ethylene fulfills all the requirements of a hormone, yet some scientists seem reluctant to grant it authentic hormonal status. Recognized hormones circulate in body fluids and sap through structured and specific pathways. Ethylene transport, on the other hand, seems to occur exclusively through gas phases inside or outside the plant. Whichever way this quibble ends, ethylene is firmly established as a remarkably active and sometimes useful plant growth substance.

many important proteins present throughout the life cycle of plants. Since methionine is always present in plant cells, control over ethylene synthesis cannot depend on the availability or nonavailability of this "precursor." The control must, instead, be exerted by the enzymes that act on methionine, which must appear and disappear during the life cycle of the plant. One lead to identification of the factors controlling the appearance and activity of such enzymes is the discovery that the typical apical hook at

the top of the stem of pea seedlings grown in the dark results from dif-

ferential growth on the two sides of the hook, which is, in turn, controlled by ethylene production in the hook. Red light perceived by the plant pigment phytochrome

causes the hook to open and also

depresses the production of eth-

ylene by the hook. The action of

red light in facilitating hook open-

ing can be prevented if the hook

region is simultaneously supplied

with ethylene from the outside.

These results seem to prove that

the opening of the hook is caused by the cessation of ethylene production. The inference is that the

enzymes regulating ethylene syn-

thesis are turned on and off by the phytochrome system. Whether or

not auxin, known to promote eth-

ylene synthesis, plays a role in this

phenomemon is unclear.

Columnist Arthur W. Galston teaches biology at Yale University.

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Secrets of Peru's Ancient Walls

Only a highly organized society could have constructed such expansive cities and massive monuments

by Michael E. Moseley



Imposing prehistoric monuments are discovered every year in the secluded valleys of South America's rugged Andes and the adjacent regions. Yet countless ancient ruins of great size probably remain buried in isolated and unexplored areas. Because South American archeology is still in its infancy, only a few of the

more spectacular sites have received thorough scientific study, and the majority of the Andean ruins remain uninvestigated and unmapped, their origins shrouded in mystery.

That unknown civilizations constructed many of the biggest pre-Columbian sites heightens the mystery. These civilizations rose

and fell long before Inca armies forged the central Andes and the Peruvian coastal areas into what was the largest native empire of the New World until it was toppled and ravaged by Pizarro and his soldiers in 1532.

Unstudied ruins of great size and antiquity naturally invite questions about their construction and their builders. Because there are few established facts to serve as interpretive guidelines, speculation is varied. Nevertheless, there are only two principal schools of thought.

The first-based on the belief that the inhabitants of the region were not sophisticated enough to have erected the more spectacular ruins dotting the landscapeholds that the monuments were the products of people and ideas that originated far away from the Andes. If the indigenous people lacked the technological and organizational wherewithal to produce the sites, then the ruins must have been the handiwork of more advanced societies that developed outside the Andes and then colonized the mountain chain, constructing great monuments and cities.

Although all diffusionists—as adherents to this school are called—see foreign influence at work in the Andes, there is little agreement among them as to where the colonists of advanced civilization migrated from. Some believe that the conceptual foundations of Andean civilization came out of the Amazon Basin or from Mexico. Others have proposed that the peoples of East Asia sailed or drifted across the Pacific Ocean to South America. Two recent attempts to cross the



When the Incas conquered Chan Chan in the fifteenth century, the city covered more than four square miles. Of its nine compounds, one, foreground, has been restored.





After Pizarro's conquest of the area in the sixteenth century, treasure hunters ransacked both Huaca del Sol, at right, and the smaller Huaca de la Luna, center left.

Atlantic Ocean in primitive reed boats have revived interest in Egypt as the fountainhead of South American cultural development. Finally, some diffusionists have carried their theory to an extreme with the proposition that astronauts from societies in outer space prompted the construction of many Andean monuments.

The opposing school of thought considers the pre-Columbian ruins to be products of purely Andean civilizations that developed locally without significant foreign influence. Adherents to this school believe evidence of contact with aliens from the Orient, Egypt, or outer space is dubious at best. The issue is a simple one: did the native Andean peoples have the technology, labor organization, and cultural sophistication to build great cities and monuments or did they not? Diffusionists assume they did not.

Indigenists, as proponents of the opposing school are called, assume that, unless proved otherwise, local populations were not only capable of building the ancient monuments found in the areas they occupied but did, in fact, construct them.

Against this background of scholarly debate, a Harvard University archeological team of which I am a member is studying two of the largest sites in South America. Huaca del Sol (Shrine of the Sun) is the biggest solid-brick platform mound ever erected in the Andean region. This great mud-brick platform and its smaller sister mound,

In this squatters' settlement on the outskirts of Trujillo, some present-day building methods are much the same as those used in constructing Chan Chan. Huaca de la Luna, were built approximately 2,000 years ago as part of a large complex. Dating about 1,000 years later, the nearby ruined city of Chan Chan on the Pacific coast is one of the most extensive ancient metropolitan centers in the New World. The two sites have long attracted attention because of their vast size and complexity, but in the past, most excavation was the work of hordes of looters who were searching for buried treasure.

Both sites are situated about 300 miles north of Lima in the Moche Valley on the arid Pacific coast of Peru. Rain is rare along the coast, and showers of consequence occur about once per decade. The terrain is bleak and treeless. For centuries, this desert valley has been farmed by irrigating it with water from the Moche River, drawn through an extensive network of canals to create a fertile oasis.

The first step in determining the origins of these two large sites was to discover whether or not earlier mounds and cities existed in the valley. If there were no local precedents for Huaca del Sol or Chan Chan, an outside origin for the sites would seem reasonable.

In 1969 we began a detailed archeological reconnaissance of the valley, which required two years to finish. During this period we found a large number of prehistoric sites. Some were the remains of isolated farmsteads and hamlets and revealed only shards, seashells, and charred animal bones. At times, however, we discovered more important ruins, half-buried by sand dunes or lost in isolated canyons.

These discoveries were important for two reasons. They showed that inhabitants of the region built mounds and lived in cities more than a millennium before either the construction of Huaca del Sol or the founding of Chan Chan. And through the local precedents for the two large sites, we learned that the concepts of urban life and monument building were not foreign.

The reconnaissance also provided an archeological record of other settlements that were already occupied when the two larger sites were under construction. This record established the broader cultural contexts of the construction of Huaca del Sol and Chan Chan and allowed us to evaluate both the size and the location of the local prehistoric population in the valley.

Although mound building and city life were not new concepts, the great size of Huaca del Sol and Chan Chan made these sites quantitatively different from their local antecedents, and this might, in theory, reflect outside influence from more advanced peoples. Evaluating this proposition required that we investigate the technology, labor, and organization involved in building these large sites. This knowledge, together with the broader cultural information we had gained through our reconnaissance of the valley, would allow us to better judge whether or not indigenous peoples were capable of constructing the monuments.

Built near the banks of the Moche River, Huaca del Sol is a platform mound, 375 yards long and of uncertain width. The towering height of the monument is accented by its isolation, the surrounding ruins being largely buried beneath a vast plain. The half-square-mile area around Huaca was first settled several hundred years before Christ, and archeological deposits have accumulated there to a depth of almost 30 feet. Shortly before its abandonment in about A.D. 500-600, the site was one of the largest population centers on the Andean coast.

After Pizarro's conquest and the establishment of colonial rule, Spanish looters, searching for hidden treasure, diverted water from the Moche River into a large canal and washed away the west side of Huaca. No one knows what they found, but their hydraulic looting completely obliterated more than two-thirds of South America's largest brick monument. Only the eastern side

of the platform survives today.

I believe the structure was originally bilaterally symmetrical along its north-south axis, and that the configuration of the now missing western portion of the mound was the same as the east side. If so, then the platform was shaped like a huge cross. When fully intact, the mound was between 177 and 328 yards wide. The top of the platform had four steplike changes of elevation. From north to south the height of the monument increased in three successive steps to an elevation of about 130 feet. At the fourth and southernmost step, the elevation dropped to about 65 feet. Where the summit has not been destroyed by looting there are traces of large rooms and courts, and it is evident that in ancient times much activity went on atop Huaca del Sol.

The mound is made of unfired mud bricks, or adobes. To calculate the number of bricks that went into the building of Huaca del Sol, our workers reconstructed the approximate size of the platform, measured the size of the average adobe, estimated the volume of the mound, and arrived at a figure of 143 million bricks. Millions of man-hours of toil were required to produce this prodigious number of bricks.

Once we had a rough idea of the tremendous labor investment involved in building the huaca, we wanted to determine how long it took to construct. If Huaca del Sol was erected rapidly and all at once, then—as diffusionists would argue—an extraneous society with a high degree of technological advancement probably built it. If, on the other hand, building went on gradually over a long period of time, then the indigenous populace could have met the labor requirements.

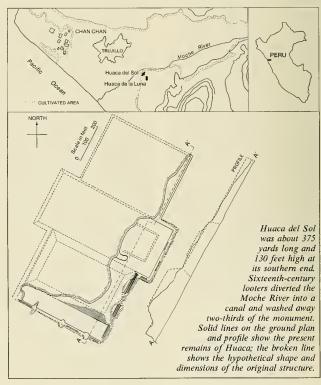
The hydraulic looting of the structure left the interior construction of the platform exposed as clifflike faces in several areas. One profile ran from the top of the platform through the base and into the underlying archeological deposit. This was a windfall for us. We were able to

begin excavations in the underlying deposits, then move to the mound summit and uncover rooms and structures there. The excavations above and below Sol bracketed the time span during which it was constructed. The pottery found in both sets of excavations belonged to a local archeological style known as Moche, or Mochica, which archeologists divide into five chronological phases, varying from about 75 to 200 years. The summit rooms produced shards of the fourth phase. The deposits under the mound yielded pottery that could date to the first two phases or to the beginning of the third.

Radiocarbon dates associated with pottery of these phases found at other sites indicate that Huaca del Sol was under construction for at least 100 years, and the time involved may well have been two or three times as long. If the ancient Egyptians

could erect a great pyramid within the rule of a single monarch, there is little reason to doubt that Andean peoples at a comparable level of technological development could have erected a vast brick platform in the course of several generations.

The long span of construction meant that the indigenous coastal inhabitants had plenty of time to erect Sol. Yet we still had to establish how the mound was actually built and the manner in which the huge work force was organized. Again, the profile left by hydraulic looting gave us some answers. Investigation of the cut revealed eight major construction stages, one atop the other. Each stage was separated from the next by remnants of rooms, courts, and cultural refuse. This meant that each period of building had been followed by a period of use during which people lived and worked on top



of Sol before resuming construction to a new height. We do not know who resided on the mound or exactly what they did, but we suppose the residents were upperclass bureaucrats engaged in administration or governance of some sort.

The clifflike brick face under study covered only a small part of the platform, and I cannot claim that the entire mound was erected in eight separate stages. When other exposures of the platform core were checked, however, a broadly similar patternof building periods followed by residence periods—emerged. These interspersed periods of building and living helped explain why it took 100 years or more to build the platform.

While studying the principal profile, we noticed that the adobes in each building stage had characteristics that differed slightly from those in earlier or later stages. In the latest five stages we found a majority of the adobes had symbols impressed on their top surfaces. These were composed of dots, straight lines, curves, or combinations thereofpresumably identification marks made by the workers or work groups who made the bricks. The symbols, which we called "makers' marks," were drawn by finger on the brick's surface while the mud was still moist and soft. By scouring the monument's surface and examining thousands of bricks, we were able to identify ninety-six different marks. Many bricks had the same mark, and this was important. Because there were millions of adobes but so few marks, we concluded that the marks identified different groups of brickmakers. If the marks identified only specific individuals, there would have been thousands of distinct symbols since producing the adobes for Sol required thousands of brickmakers.

The use of these marks is not surprising in a society that lacked writing. Enormous numbers of bricks were needed for Huaca del Sol, and the easiest way of keeping track of the quantity of bricks produced by each group was to use makers' marks.

We also discovered that the masonry in each construction stage of the platform had been laid down in vertical segments. Each segment was some four to ten bricks wide and the same height as the construction stage. Adjacent segments were not bounded by interdigited bricks; each segment was independent and separated from the next by a narrow, vertical gap.

Segmentation could not be explained on the basis of engineering or technology. Dividing a construction stage into discrete modular units made little sense until we observed a patterned relationship between the segments and the brickmakers' marks. The adobes in a particular segment all had the same symbol while bricks in an adjacent segment had a different one.

We also discovered that the soil quarried to make the bricks came from several different areas. Most bricks were brown, but many were yellow or gray. The bricks in each segment not only had the same mark, they were also of the same soil type.

This triple correlation of segments, marks, and soils suggested that the group that produced bricks with a particular mark was also responsible for transporting them to the construction site and laying them up in a particular segment. A specific group of people was assigned the task of building one or more segments of a construction stage, and this group had to produce, transport, and lay up its own bricks. If the division of labor had been different, then the bricks would have been mixed at the construction site or by the masons, and the correlation of soils, marks, and segments would not have existed.

At this point we needed to know if segmented building was typical of other prehistoric construction projects. During the archeological reconnaissance of the valley we had located a number of adobe platforms built before and after Huaca del Sol. Examination of these structures

showed that building in vertical sections was typical. The bricks lacked marks, but there was a correlation between adobe soil types and segments. Apparently the principles of labor organization used in building Huaca del Sol also applied to the other mounds.

Further confirmation of this building method came our way with the discovery of several ancient canals that had not been completed because of engineering errors in calculating the water flow gradients. These abandoned conduits were also constructed in segments. In the largest waterworks project, 165- to 290-footlong completed trenches were interspersed with undug segments of comparable length. The unexcavated sections often had rocks lined up along each side of the intended canal course to show the different work groups where to dig.

The great walled adobe city of Chan Chan exhibits elements of the same labor organization. At this site, ancient structures are scattered over a large area; the nucleus of the city covers an area of more than four square miles. The site is dominated by nine high-walled, rectangular enclosures, 230 to 655 yards long. Some of these walls still stand to heights of more than 25 feet. Symmetrically arranged rooms, courts, and plazas-interconnected by mazelike corridors and narrow halls-were built inside these high enclosures.

The excavations we opened indicate that the city was founded several centuries after the abandonment of Huaca del Sol. Sixteenth-century Spanish priests had recorded the local Indian lore that Chan Chan was the capital of an empire that stretched along the Pacific coast from southern Ecuador to modern Lima. A long dynasty of monarchs, each of whom we think built and lived in one of the great enclosures, ruled the city and its outlying settlements. About 1465 the sprawling Inca empire swept up the coastal dominion. Although deprived of its

imperial status, the city continued to thrive under Inca hegemony and was abandoned only about the time of Pizarro's arrival.

The origins of Chan Chan can be explained without invoking astronauts or transoceanic mariners. The city was built and occupied over a long period, and as the imperial capital of the largest pre-Inca empire in South America, its rulers could mobilize great work forces for different construction projects.

Initially we thought that the workers who built Chan Chan were organized in a similar manner to those who constructed Huaca del Sol. There was a significant difference, however, between the two sites: one was a platform mound; the other was a complex of walled enclosures. The massive enclosures of Chan Chan reveal a series of vertical bamboo or cane poles set in the center of each wall and spaced at intervals of about twenty feet. Some scholars had suggested these were the stumps of flagpoles that once supported ornamental banners. But we turned up small buildings, both inside and outside the great compounds, with vertical poles spaced along the wall centers. Where the walls were preserved to their original height, the poles did not project above the wall top. Where the poles were set we also found vertical seams in the masonry at right angles to the direction of the wall. We further detected minor differences in the adobe soil types on different sides of the seams. There was apparently a pattern of linear segmentation with a vertical pole marking the end of each section. In a general sense it embraced the same principles of segmentation found in canal building and in the construction of Huaca del Sol.

Construction by segmentation probably was typical of many different types of prehistoric construction projects executed in the Moche River Valley: a specific wall segment corresponded to a specific work load assigned to a particular group of people. At Huaca del Sol, brickmakers'

marks suggested that the task of constructing a segment of a project included producing adobes, transporting them to the site, and then completing a particular section of masonry. This meant the individual work gangs responsible for a particular task must have been large. We also discovered that in some cases the same brickmakers' marks were used in two or more successive construction stages. This implied that the same groups of people worked together over a generation or more.

I suspected that members of a specific village or community were assigned to construct a segment. We were able to evaluate this proposition at Chan Chan. Buildings erected at the city after the Inca takeover show the same pattern of linear segmentation typical of earlier structures at the settlement. This indicated that the system of labor organization used before and after the Inca arrival was basically the same.

In pre-Columbian times Andean societies did not use either currency or a standardized monetary system. Spanish chronicles record that the Inca state extracted revenue in the form of labor, and to meet their obligations, members of specific villages had to undertake specific tasks assigned by the government. If this tax system was maintained at Chan Chan after the Inca conquest, and if the segments represent the work loads assigned to different communities, then the continuity with earlier segmented construction suggests that an analogous labor system was in use before the city lost its sovereignty. I would further argue that such a labor tax system was used to mobilize the work force needed to build Huaca del Sol, and that, in this case, members of the same community used marks to identify the adobes they made for an assigned construction segment.

The indigenous labor system also appeared to survive the Spanish conquest, at least in part. When Pizarro's men took control of the Moche Valley, they

Because of the region's arid climate, Chan Chan's walls have eroded slowly. Some are still 25 feet high and 2,000 feet long.

founded the colonial town of Trujillo. About a century later pirates became active along the coast. They not only preyed on Spanish shipping but also sacked several port settlements. In 1686 the pirate threat prompted the citizens of Trujillo to build a defensive wall encircling the city. This adobe fortification had a circumference of more than three miles: hundreds of thousands of bricks were needed for the project. The municipal government assigned the job of producing the adobes to the Indian population, and the work load was divided among eight different communities so that each native settlement made up a separate unit of brick production.

Today, Trujillo is a thriving commercial center, and the Moche River Valley is now occupied by mechanized sugar plantations. Yet in remoter parts of the Andes there are many Indian settlements where traditional ways of life still exist, and customs include community-based labor obligations to construct and repair particular sections of roads, bridges, canals, and public build-

ings.

Each Andean ruin has a different story to tell. But I doubt that these stories will ever include astronauts, Oriental mariners, or expeditions of ancient Egyptians. We have studied in detail two of the very largest monuments ever built in the Andes, followed their origins and construction through time, and brought to light the organizational principles by which they were erected. If Huaca del Sol and Chan Chan were produced by indigenous societies, there is little reason to doubt that other, unstudied monuments of the Andes also were well within the engineering and organizational capabilities of the native inhabitants.



The Victorious Coyote

by Pamela McMahan

In their relentless pursuit of this intelligent animal, some humans are unwittingly selecting a breed that is able to expand its range.

Armed with guns, poisons, traps, and other weapons, America has waged a continuous war on coyotes since the middle of the nineteenth century. Against this vast human arsenal, these versatile animals could rely only on their own humble armaments—intelligence, endurance, and adaptability. Perhaps coyotes have been better equipped than humans in the long battle, for they have by no means been defeated but have, in fact, prospered.

Other predatory species similar to coyotes have not done as well. The wolf, the coyote's close relative, is nearly extinct in the lower forty-eight states. In a direct confrontation between a coyote and a wolf, the latter, with its supe-

rior bulk and strength, is the easy victor. But in the battle with humans, the coyote has emerged victorious. Coyotes have not only survived the onslaught, they have increased their range dramatically, incorporating much of the area previously occupied by wolves.

Although similar in many ways, coyotes and wolves display distinctly different social behavior. Wolves have evolved into complex social animals and typically live in packs. Wolves can form social bonds when they first meet, even if they are members of the same sex. Continuous association, rapid development of a hierarchy, and coexistence ensue. Physical contact is common and functions as a positive reinforcement of the social order.

Coyotes, however, do not readily accept each other's company; they commonly segregate into singles or pairs. If disturbed, they may seek a common refuge, but contact between the animals





When hunting, coyotes often listen for mice under the snow. Upon hearing one, they typically pounce, trapping the prey under their front paws.

while at the refuge is incidental. Family groupings do occur, however, and these kin groups can develop into social organizations that resemble packs. In such situations, even though a hierarchy develops that maintains a social structure and reduces the number and severity of fights, the animals are not as social as wolves.

When coyotes are resting, they rarely engage in physical contact. Although very young pups sleep with their bodies touching, and slightly older ones often playfully fight, most body contact is restricted to fights between strangers, greetings, mating, and playing within male-female pairs and family groups.

There is evidence, however, that coyotes have not always been unsocial. Typically solitary animals, such as bears, lack obvious or complex expressions. No selective pressures existed for the evolution of complex communication systems that attract the animals to one another.

Coyotes, however, like wolves, show a vast array of vocal, facial, and postural expressions. This repertoire suggests that coyotes were at one time inclined to be more social than they ordinarily appear to be today. Early accounts of coyotes indicate that large bands were fairly common. Some selective pressure must account for this shift from a social to a more solitary existence.

Today, cohesive family groups are most often found in remote areas or locations where coyotes are relatively unpersecuted. Solitary coyotes also reside in such areas. But where coyotes are harassed or frequently disturbed, family groups are rare. In such locations, offspring may even separate from their parents when they are only a few months old.

Since covotes are capable of both semisocial and antisocial behavior, they can adjust their density according to the dictates of their environment. Availability of food, for instance, may affect the level of sociability. More solitary coyotes, however, have probably been the more successful survivors and breeders during the past 100 years since social animals are more susceptible to depredation by human hunters. A group of animals is more likely to be observed than a single animal not only because of the actual number of individuals but also because of the increase in signs, such as tracks, feces, and vocalizations. Social attachments among group members further increase the animals' susceptibility. By coming to the aid of an injured or captured wolf, other wolves have exposed themselves to hunters. In view of the increased vulnerability of large numbers of animals, coyotes are most threatened by direct kill methods as family groups during the denning season.

Although coyotes are generally assumed to be territorial, one of their most prominent traits is their mobility. They cannot be described as strictly nomadic, however, for most tend to settle in a particular area or at least confine their wanderings to a limited range. Depending upon local conditions, individual coyotes apparently adjust their ranges, oc-

cupying smaller areas when food and shelter are more abundant. Coyotes may change locations seasonally; a pair often returns to the same den site in the spring of each year even though they were not seen in that area during the fall and winter.

Every coyote is surrounded by its personal space—the area immediately adjacent to the animal regardless of specific location. When coyotes fight, they are probably defending this space, as encroachment by another coyote is not tolerated.

Coyote parents are gentle and protective. If threatened, they will protect their young or, if necessary, move them to a safer location. If one parent is killed, the other will continue to raise the young. The male coyote shares all parental duties and will even relocate the pups although he is less inclined to do so than the female.

The reproductive and breeding traits of coyotes have probably contributed to their greater survival success. Wolves mature in their second year, but coyotes can breed when less than one year old, thereby increasing their reproductive potential. Also, the social organization of wolves dictates the breeding success of individuals; a dominant female in the hierarchy may interfere when a lower-status wolf attempts to mate. Such a lack of harmony decreases the number of litters produced, and the reproductive potential of the pack is rarely attained.

By contrast, just one mating coyote pair usually occupies a given

Coyotes, like wolves, communicate by howling. Often, they will even respond to the sharp, high-pitched honks of a car horn.



If a lone coyote and a pair cross paths, a fight will usually ensue. The male of the pair will attack a lone male; the female of the pair will attack a lone female.

area, so each pair is able to breed without social interference. Coyote litters average five or six offspring, but larger litters are not uncommon, and up to nineteen young have been recorded for a single litter. Some evidence suggests that, within limits, litter size may be inversely related to population density.

Like most members of the family Canidae, coyotes are potentially long-lived, surviving ten to fifteen years in captivity. Few wild coyotes live more than eight

years. Age distributions of natural coyote populations suggest that mortality is highest during the first year, remains relatively high during the next two years, and then tapers off for the remaining years. Natural mortality is caused by lack of food, disease, parasites, and interspecific and intraspecific strife, although the degree of the latter is difficult to assess.

Another reason for the coyote's success is its varied diet. Wolves tend to consume meat from large

species. In some cases, 60 to 90 percent of their diet consists of large herbivores, with smaller herbivores making up the balance of their food source. To capture large prey, wolves usually depend on each other, whereas a solitary wolf must seek out other food sources. Although coyotes also feed on large herbivores, such as deer and sheep, a greater proportion of their diet consists of smaller species, mainly rabbits and rodents. Because of this preference, coyotes in pastures and





JEN AND DES BARTLETT; BRUCE COLEMAN, INC.



DAVID HISER

grain fields benefit some farmers.

Coyotes, like wolves, consume carrion as well as fresh meat. They will also feed on insects and vegetation if no other food is available. Some coyotes develop a particular fondness for fruit. Although pairs or groups of coyotes may hunt together and cooperate in the capture and consumption of prey, they are not restricted to this hunting method. Many animals are small enough so that a single coyote can easily subdue them, but even lone coy-

otes can kill larger prey species.

The ability to adapt to various temperatures has also helped the coyote to survive. Coyotes live comfortably both on the deserts of the southwestern United States and in the mountains of Alaska, and they are at home in rural and urban areas. According to residents of Los Angeles, coyotes are plentiful within the city limits. Other predatory mammals, even mountain lions, are occasionally captured in residential areas of Los Angeles, but only

coyotes have so completely adapted to urbanization.

Often curious, a coyote is compelled to investigate new situations. If it does not feel threatened, a coyote may display incredible audacity—venturing into suburban backyards, rumaging in trash cans, raiding gardens, and even snatching unprotected pets.

Related to the animal's adaptability is its physical endurance and strength. Seemingly tireless, coyotes can trot for hours; their

Always curious, a coyote will investigate anything that moves. One spraying from a skunk, however, will teach it to keep clear of this animal.

This coyote is hunting for rodents, the major portion of its diet. Their reliance on this food source, rather than on large herbivores, may be one reason that coyotes are more numerous than wolves.

stamina is almost unparalleled. Studies in which coyotes are captured, marked, released, and recaptured indicate that they can travel up to 100 miles over periods of several months to a year. In fact, they travel much farther since the distances in these studies are measured in air miles. Having supple bodies, which allow for agile movements, coyotes can swim, leap, burrow, and run with comparable ease.

The ability of coyotes to withstand physical anguish is legendary. A list of infirmities that coyotes have conquered illustrates both the endurance of coyotes and the inhumanity of humans. The animals have had their jaws broken, shot off, cut off, or wired together. Traps have severed or broken one or two legs. Scalped and left for dead, they have recovered. They have even been known to cope with total blindness. Even after suffering such injuries, some female coyotes have raised healthy pups.

A coyote's small stature serves it in many ways. Obviously, a small animal is less noticeable than a larger one, and a cautious coyote can give a fair imitation of invisibility. Perhaps even more important, small animals are less likely to induce fear in humans.

Unfortunately, however, coyotes often inspire hatred and disgust. Legends of "evil" coyotes have influenced some people. Others are motivated by coyote predation on livestock or poultry. Yet many people admire these handsome, intelligent creatures.

Coyote intelligence is demonstrated by the ability of captives to solve puzzles and work out complex situations. For example, a coyote will jam an object into a nearly inaccessible position, then

diligently work to extricate it. If a human retrieves the object and returns it to the coyote, the animal will invariably replace it and repeat the extrication procedure. Since a captive coyote cannot hunt for its food, these games may provide outlets for search and capture behavior.

Trappers' tales further illustrate the resourceful nature of coyotes. The animals have been known to uncover every trap in an area and secure the bait without being caught. In areas where ranchers have impregnated sheep and deer carcasses with poisons and surrounded them with traps, some coyotes no longer eat deer or sheep carrion, even if the animals died of natural causes. These coyotes may have learned to avoid carcasses because they sense danger, or by killing coyotes that prefer carrion, humans may have unwittingly selected those animals that prefer fresh meat.

Even their playfulness marks coyotes as intelligent creatures. Play behavior in mammals is usually confined to infants and juveniles. Species in which adults are playful are rare. When play persists in adults, as in dolphins, the species is recognized as exceptionally intelligent. Within kin groups coyotes frequently exhibit this behavior, playing with each other or attempting to capture leaves, rocks, water, or anything that moves.

Like all animals, coyotes combine instinctive and learned behaviors. Predation techniques provide an example. With no prior experience or parental guidance, coyotes will pounce upon rodents, leaping completely off the ground and landing on the prey with both forefeet. Coyotes also react innately to small, flee-

ing animals by immediately pursuing and, if possible, attacking them. Yet some training or learning may be necessary before coyotes are able to attack larger prey, since inexperienced coyotes typically flee from animals larger than themselves.

Their inclination to flee, however, may be countered by the prey's escape response. If an animal runs away from a coyote, the coyote will probably give chase. Also, a coyote's previous diet may affect its responses; if it has once fed on deer carrion, it may more readily attack a live deer. Some coyotes have no fear of sheep and, in captive situations, have been known to bed down with them.

Today, coyotes and, possibly, bobcats are the only prevalent predators in the United States able to tackle animals larger than rabbits. When wolves were eliminated from large regions of America, an ecological void was created. Coyotes moved in and partially filled that void. But evolution has not provided us with an unlimited supply of predator substitutes. Each removal of a predatory species brings us closer to the total extinction of all predators. The ultimate effects of predator elimination cannot yet be prophesied. Localized predator extinctions or absences, however, suggest possible results.

In the United States, large herbivores, such as elk and moose, evolved with predators. When deprived of predators, the populations of these herbivores usually increased rapidly. Eventually the requirements of the expanded populations exceeded the available resources. As the food supply was depleted, starvation followed, causing a drastic decline

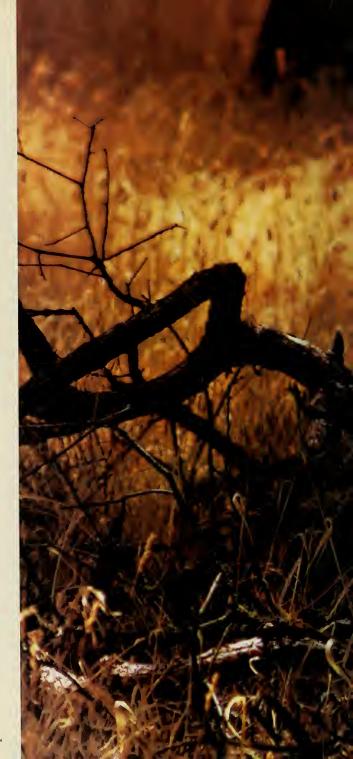


Small and unobtrusive, the solitary coyote blends into its surroundings and avoids hunters. Yet it is large enough to kill its prey alone.

in the number of herbivores. Some populations were able to increase again, but in other cases changes in amounts and types of vegetation permanently lowered the carrying capacity of the habitat. A similar situation occurred when rabbits were released in Australia. The rabbits rapidly multiplied and exploited the habitat. Australia's native predators were unable to check the population explosion of rabbits.

The removal of a predatory species can also lead to a decrease in the number of former prey species and an increase in the population densities of successful species. Competition among prey species may be the vehicle for these changes. The more successful species, no longer restrained by the predator, are able to multiply. Either directly or indirectly, they then eliminate their rivals. Indirect competition is probably most significant; the successful species command larger shares of the available resources. The net result of this process is a decrease in the diversity of the ecological system.

Although coyotes now occupy their maximum geographic range, their density has decreased in many areas. Despite their present high over-all population, the coyotes' future survival is not guaranteed in the face of new control methods and killing devices that are still being developed. A species is vulnerable to extinction even though it is represented by millions or even billions of individuals. Great auks and passenger pigeons are examples; both were hunted to extinction in spite of their former abundance. Admittedly, these creatures did not possess the intelligence or adaptability of coyotes. Nevertheless, envisioning an America without coyotes is neither absurd nor unrealistic.







Designing Women of West Africa

by Lisa Aronson

Despite commercial tints and machine-made cloth, the art of fabric dyeing remains a flourishing tradition

John Barbot, a French explorer, was so struck by the complex indigo-dyeing process he observed while traveling along the West African coast of Guinea in 1732 that he recorded its details in his journal. The women, he noted, gathered leaves from a bush and pounded them in deep, wooden mortars. The macerated product was dried in the sun for several days, pounded again, and dried a second time. Mixed with ashes and water and set in the sun, the result was a thick, blue dye. Today, more than 200 years later, a visitor traveling in the Gambia River area is likely to encounter women using essentially the same dyeing techniques that Barbot observed.

Since no one has as yet determined the origins of the dyeing industry in Africa, its history is still incomplete. The earliest evidence we have of its existence in sub-Saharan Africa dates from the sixteenth century, when Portuguese explorers told of locally processed blue cloth being transported inland from the west coast toward the Sahara.

Of course, it wasn't until the sixteenth century that the Portuguese began recording detailed observations of Africa. Nevertheless, the dyeing industries they observed seemed well established, suggesting that dyeing existed prior to their presence in Africa.

Existing collections in European museums enhance the written evidence-understandably so, since European explorers brought back artifacts, including cloth, to their own countries. These textiles represent the earliest examples of fully intact weaving from Africa. The only other evidence of African dyeing is obtained by studying the history of the weaving industry, in which dyeing played an integral part. For this we must look at the history of the Portuguese presence on African soil.

In the fifteenth century, the Portuguese, searching for gold, hoping to find a route to the spice trade of the Indies, and perhaps on a mission to spread Christianity, made their way to the west coast of Africa. By the 1450s, Portuguese explorers had reached as far south on the coast as the Cape Verde Islands. Shortly after, they began establishing commercial ties with the Africans, including among other things, the trading of indigo and cloth. The Portuguese

were amazed to find African artifacts and products as refined as, if not superior to, their own. They discovered an indigoprocessing tradition among the women and a weaving craft among the men so well developed that there was little more to do other than supervise the manufacture, distribution, and export of the cloth.

Slaves from various tribes—the Wolof, Mandingo, Fulani, and particularly, the Banhuns and Casangas, who were purported to be the most skilled weavers and dyers-were commissioned to produce the cloth. Because the dry climate of the Cape Verde Islands, just off the coast of Senegal, was most suitable for the cultivation of cotton and indigo, these islands became the most specialized area for the production of cloth and indigo. Indigo was prepared, as Barbot described, by grinding the leaves and stems of the indigo plant (Indigofera), then forming the substance into small, dry cakes, which the Portuguese called tinta. When it was ready to be used for dyeing, the tinta was fermented with an ash substance plus water and stored in a large clay vat. Another plant, commonly called woad (Isatis tinctoria), whose leaves created a slightly paler blue dye when processed, was also exploited on the islands. The entire dye-making process took



Traditional tie and dye: The fabric is secured in a series of tight knots, left, then dipped in the dye bath. To achieve the mottled pattern, below, the dyer created a resist by splashing wax on the fabric, then dyed the cloth brown. The squares were stenciled on with indigo. Standing in front of drying batik cloth, right, a Gambian woman wears a tie-dyed sundress of Western style with a traditional head cloth.



from three to six weeks.

The early Portuguese explorers also encountered a complex trading system already in operation on the African mainland. Traders, mainly of the Mandingo tribe, traveled along designated caravan routes that stretched from the Senegal-Gambia area east to the southern Sudan, and their already flourishing trading patterns were ideal for facilitating the movement of dyes and cloth to the interior.

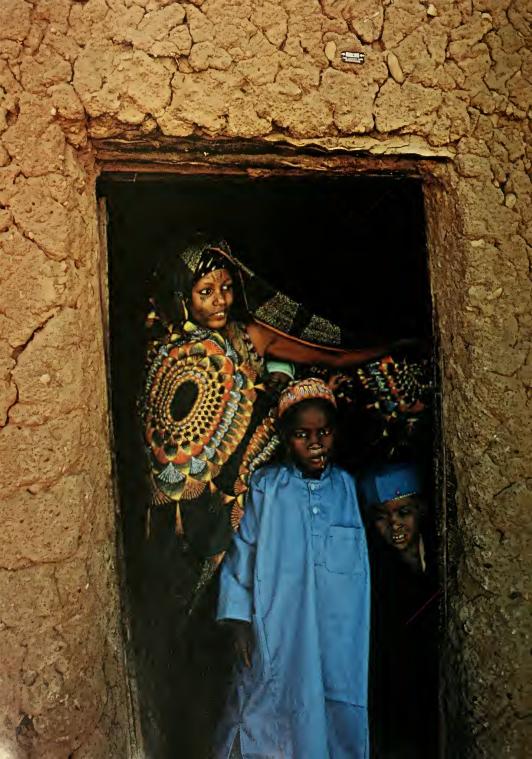
The cloth produced on the Cape Verde Islands and along the western Sudan—known today as "country cloth"—consisted of numerous narrow bands approximately six inches wide, which were sewn together lengthwise to a standard size of sixty by ninety inches. The narrow strips were woven, as they still are, by men using portable, horizontal foot-treadle looms. The cloth was either solid blue or composed of blue, white, and occasionally, brown stripes, the

brown dye presumably made from the kola nut. Dyers tinted the cloth after it was woven or they dyed skeins of spun cotton, which were then warped on the loom and woven to create the striped patterns. This process was so standardized and efficient that by the late seventeenth century cloth production had become a major industry for the people of West Africa, and remains so to this day.

As further proof of its economic value, cloth, like salt

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Although machine-printed cloth is becoming more common in West Africa, the designs, such as on this Nigerian woman's dress, are often derived from tie-and-dye patterns.

and iron, assumed monetary importance for the Africans. Sometime in the early nineteenth century, the Wolof of Gambia began using cloth as a standard medium of exchange, and the Cape Verdeans were using cloth as money even earlier than that. Using their portable horizontal looms, the weavers were able to produce standard units of cloth that were transportable and capable of being produced in great quantity. The use of cloth as a standard denomination, or value, lingered until late in the nineteenth century. The presentday Wolof, in fact, recall that plain white strips of cloth were the standard medium of exchange, whereas dyed cloth had a considerably higher worth, and dyed cloth with designs held the greatest value of all.

In most areas of West Africa today, the women perform the dyeing, as they have done traditionally. Young girls, under the guidance of mothers, aunts, or grandmothers, learn the intricacies of preparing the dyes and develop a sensitivity to the amount of dye needed for coloring the cloth. Having served this apprenticeship, they may then work on their own. Experienced dyers may work individually or, if they choose, in a cooperative capacity. The latter is preferable since it is difficult for a single woman to acquire enough capital to maintain her trade. A woman who prepares herself for the dyeing profession is aware that she is entering a profitable and much respected trade and, after years of working with the dyes, will be proud to exhibit her hands stained a telltale blue.

Much of the apparatus she uses, like the deep, wooden mortars used to grind up the dye

substance or the double pot device that allows the dye to pass through to the bottom, was mentioned in the early histories, but there is newer equipment as well. The clay pots once used for storing the dye solution have been replaced by metal washbasins. Wolof women still practice the traditional method of preparing indigo, but more and more, they use imported European dyes, which can be purchased in the shops. In addition to the standard blue and reddish brown, a rainbow of colors has flooded the industry, imparting an entirely new aspect to the dyeing process. Although such hues as cerise, apple green, gold, purple, red, magenta, and others have been introduced into the color schemes, indigo remains the preferred color.

From only one vat of indigo a dyer can control a range of blues. If the cloth is dipped momentarily into the vessel, the solution will be only slightly absorbed, and the cloth will be a pale blue hue. By leaving the cloth in the vat for a longer period, the dyer can create a deeper color. The most prized intensity is the blue-black that results from leaving the cloth in the indigo for up to a week. The cloth may then be beaten with a wooden mallet, and the almost black fabric takes on a lustrous finish. Such fabric merits a high price in the market.

Today, a noticeable feature of the dyeing industry is the process of resist dyeing. Resist dyeing is any method-tying, folding, sewing, binding, or applying substances-that prevents the dye from coloring certain areas of the cloth. Little evidence of such a tradition has been recorded in the early literature, but in the collection of the Ulm Museum in Germany, one piece, dating from 1650, is clearly a tie-dyed cloth, its origin presumably Dahomey. By the nineteenth century, resist dyeing was flourishing, as evidenced by the numerous examples brought back by missionaries and explorers.

Essentially, Wolof women use

four techniques of resist dyeing—plangi, sometimes referred to as tie dye or binding; fold and tie; tritik, or fold and sew; and several variations using starch resist and collectively known as batik. The dyers, however, also combine and elaborate on these to create a varied and intricate array of patterns.

The basic plangi is done by pinching up small tufts of cloth over the entire surface of the fabric. Traditionally, each tuft was secured by winding raffia fiber tightly around the base, but today the women use thread. Frequently they insert a small or medium-sized bead or a grain of rice in the tuft. The dyer may also fold the cloth in half and gather one large tuft of material from the center. She binds this protruding portion in several areas so that when dyed, bold, concentric circles result. If a second or third dyeing is preferred, the dyer must let the cloth dry completely, then retie it in the areas where she does not want the dve to take.

By carefully folding the cloth accordian fashion and wrapping it tightly with rope to secure the folds, an entirely different effect is achieved. The Wolof call this technique dor. The folds, which can be quite small and not always evenly spaced, result in a series of narrow vertical or diagonal stripes with perpendicular lines created by the binding material. Uneven folds (deliberately done) create an interesting pattern of undulating lines. Occasionally, the dyer bunches the cloth into a ball and tightly binds it in all directions with raffia or string until it becomes a hard, solid mass. The result is a dazzling marble design. Repeating the process allows for a second color.

The use of stitchery in addition to folds adds a new texture to the fabric. By pinching narrow folds together along the length of the cloth and securing them with a series of tight whipstitches, a woman can create row after row of a lozenge-shaped motif.

Because of the scalelike aspect of

the pattern, it is referred to as the "serpent skin" design and is very popular in the Senegambia area. The dyer may also arrange narrow folds across the length (as with the *dor* technique) and then sew across them transversely with thread. Depending on the uniformity of the folds, the

In Gambia women are the exclusive dyers, but in parts of Nigeria, men color fabric. A standard design—concentric circles on indigo cloth—is created by pinching up tufts of fabric and securing them with raffia before dyeing. The rinsed cloth is then dried in the sun.

resultant design is a series of fine, straight, or wavy lines with perpendicular white dots.

One method that differs considerably from all others involves the use of a resist paste made from rice or cassava; which the dyers apply to designated areas of the cloth. It functions in the same way as the tying or sewing-creating a resist to the dye-but it also allows for more controlled, linear patterning. The dyer simply sprinkles the paste onto the cloth or spreads it with a comb to make an interesting free-form design. Working the comb in a series of half-circular motions over the surface creates an effective three-dimensional "op-art" design. After the rice paste has dried, the cloth is dipped in the dye and left to dry in the sun. What dried paste does not fall off naturally can be removed by several washings in hot water.

Although it is not the custom for women to weave on the horizontal strip loom, they often transfer the woven geometric patterns of men's weaving to their cloth by copying the designs and painting them on the cloth with the rice paste. One special type of dyeing that requires male labor is stamp dyeing, or block printing. Throughout Africa, men, not women, traditionally work with metal and metal tools, so that the casting of metal objects, carving of masks and figures, or for that matter, any type of wood carving is done by men. In Gambia and Sierra Leone, where block printing is done, one often sees men carving relief patterns on small blocks of



wood. The transference of the pattern to the cloth is then very simple: the woman dyer merely grasps the polelike handle attached to the back of the block, dips it into the rice paste, and stamps it onto the cloth, repeating the process until she has covered the whole surface. She then proceeds as she would with free-hand batiking-dipping the cloth into the dye vats, rinsing it in warm water to wash off the resist, and drying it in the sun. Although the block itself takes time to prepare, this procedure is very practical since the stamp can be used over and

Dyeing the cloth is only part of the artistic process; the final test of the fabric's beauty is the effect it creates when it is worn. A Wolof woman traditionally wears at least three pieces of cloth-an undergarment (wrapped around the waist and reaching to the ankles); a robe, or boubou (a simple circular-necked, sleeveless blouse, which flows down to the knees); and a head wrap. For a fuller effect, she may also add a rolled cloth around her loins under the boubou and cover her shoulders with an additional wrap. The head cloth, which can be styled in a variety of ways to create bellowing, turbanlike forms, is crucial to the over-all effect. Men also wear their version of the boubou over trousers and a shirt. It is similar to the women's but considerably longer and more ample. Although Western-tailored dress, some of it fashioned from handdyed fabrics, is beginning to replace the wrapper style, women

and men of rank still wear traditional dress during important ceremonies.

With the influx of European and, more recently, Indian, Chinese, and Ivory Coast machine-made cloth in the markets, as well as commercially made dyes, it is difficult to predict how long the dyeing tradition will flourish in West Africa. For now, the imports are adding new and exciting dimensions to the art. Liberians, for example, extract the ink from ditto sheets to dye their traditional rice bags, and Wolof women superimpose resist patterns on machine-printed cloth. Hopefully, the craft will continue to expand in creative ways-incorporating the new materials, while retaining its indigenous style and beauty.



Tahoe's Troubled Waters

by the Tahoe Research Group

When a crystalline lake in the Sierra Nevada is the arena for interstate politics, the ripples may be felt at the microscopic level

"We had a beautiful view of a mountain lake at our feet . . . so entirely surrounded by mountains that we could not discover an outlet. . . Immediately above the eastern mountains was repeated a cloud-formed mass of purple ranges, bordered with bright yellow gold; the peaks shot up into a narrow line of crimson cloud, above which the air was filled with a greenish orange; and over all was the singular beauty of the sky."

John C. Frémont

"Well, when the slots clean me out at the casino, I go down and soak my feet. Sure feels good."

A gambler

"Skiing, man. Squaw, Heavenly, Alpine. You can see it from the tops of the lifts, lying there all blue. Especially at Heavenly, coming down Gunbarrel, you ski right down to lake level at the bottom."

"Lake Tahoe is being polluted. To deny this is comparable to saying that a man receiving a daily dose of arsenic in his breakfast coffee is not being slowly poisoned."

A limnologist

Lake Tahoe: On the border between California and Nevada. Maximum depth, 1,645 feet. Altitude, 6,225 feet. Shoreline length, 71 miles. Total area, 192 square miles.

An atlas

Lake Tahoe half fills a mountain valley in the Sierra Nevada range. It is cold and clear and has a remarkable blue glow usually associated with the deep waters of the South Pacific. Among the world's lakes, its only rival for clarity and color at a comparable high altitude is Crater Lake, Oregon, which is considerably smaller. The original Indian inhabitants of the region knew Lake Tahoe; in fact, they named it and many of the surrounding features. Early visitors to the lake, including the explorer John C. Frémont, the first white man to view it, recorded their delight at discovering the beautiful, isolated region.

Today, 30,000 people are permanent residents around the lake, and another million or so visit the region each year. Despite the increasing population in the Tahoe Basin, the lake is still incredibly clear. Tahoe is so pure that concentrations of essential biological nutrients, primarily nitrate and phosphate ions, are insufficient to support the algal growth that clouds most other lakes. But there are serious questions about the lake's future.

Large-scale construction can lead to massive disturbance of soils and vegetation. Construction sites left unprotected against the stormy mountain climate allow immense quantities of sediments and dissolved nutrients to wash into the lake. Will ongoing urbanization in the basin provide these nutrient materials in ever increasing quantities and eventually turn the lake green with algal growth? Not necessarily. But the Tahoe ecosystem is fragile and requires special handling.

In any attempt to describe the ecosystem of Lake Tahoe, both the cultural and natural characteristics of the region must be considered.

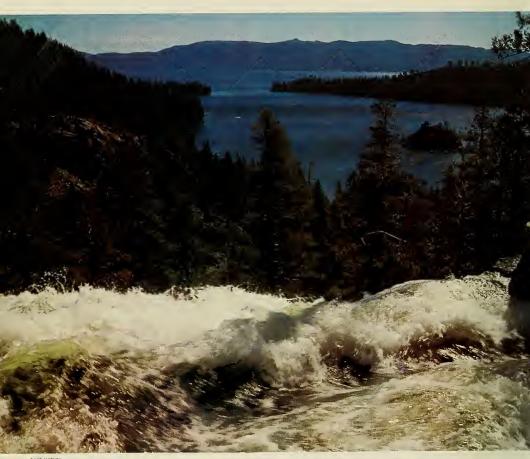
The cultural aspect includes interactions among political powers, local economic interests, environmentalists, and the human traffic attracted by the gambling industry in the region. The natural aspect is embodied in the lake itself and in the ecological relationships between lake biota and the surrounding terrain.

Human population pressures from neighboring urban centers are focused on the lake basin and have produced a microcosm of worldwide problems in urbanizing lake environments. Because of this, Lake Tahoe is of great interest to ecologists, and considerable research effort has been directed toward establishing the ecological past, present, and possible future of the lake.

Much of the work at the lake has been carried out by the Tahoe Research Group under the direction of limnologist Charles R. Goldman of the University of California at Davis. We are making a major effort to establish present standards of lake biology, so that changes can be accurately measured. Whatever the results, the Tahoe studies will have more than local impact, since they should help us to understand other regions such as the Great Lakes, Lake Powell, and Lake Mead.

Since 1959 Goldman and his associates have made more than 6,000 measurements of algal productivity at Lake Tahoe and have documented a 25 percent increase in algal growth rate between 1967 and 1971. If the data are interpolated with the earliest measurements, the change is about 50 percent over 1959 productivity levels. Despite this evidence, a land developer can still say that, as far as he can tell, the lake is essentially unchanged as a result of past de-





DAVID MUENCH







MARTIN HOOVER



ANDE DEVELOPMENT CORPORATION



Attracted by the numerous recreational activities at Tahoe, including boating, skiing, and gambling, motorists throng to the lake from nearby urban centers. Such development not only mars the natural beauty of the area but also poses a threat to the lake's purity.



Some wastes enter the lake naturally. Swollen by snowmelt, Eagle Creek Falls carries torrents of water, as well as sediment and dissolved chemicals, into the lake basin.

velopment; therefore his proposed construction cannot harm the lake.

We are fortunate that damage to the lake is as yet difficult to see and to measure, but the scientific evidence makes a strong case for serious problems in the future, a case that could not be argued before planning agencies if the data did not exist.

From the example cited above, it is clear that to develop local policy the Tahoe population and its agencies must have answers to fairly technical questions. How much algae is normally in the lake? How much phosphate and nitrate? What levels of new algal growth caused by development in the region can or should be tolerated? Some of these questions are simple to answer, requiring only straightforward chemical and biological analysis. Questions concerning tolerable pollution levels, however, are more difficult, since they involve opinions of various groups with different interests.

Our understanding of the natural history of Lake Tahoe has resulted from application of physical, chemical, and biological methods. The basic knowledge of lake processes is best expressed in terms of balances, or equations, between interacting forces and processes. An example is the balance in the basin between influx and efflux of water. Lake Tahoe, as we know it today, originated at the end of the last glacial period after volcanic action dammed the huge graben fault depression that forms the Tahoe Basin. At present, many streams bring snowmelt into the lake basin, and water is lost through the lower Truckee River and by evaporation. What does this mean when expressed quantitatively? When the various rates are measured and balanced, it turns out that less than 0.2 percent of the lake volume is lost and replenished each year. If the lake were emptied, it would require about 700 years to refill. For all practical purposes, anything that enters the lake, whether naturally or artificially, remains there.

Many physical measurements must be performed on the lake and its tributaries to permit even the approximate calculation described above. One of the most important physical events occurring in the lake basin each year is the annual influx of snowmelt from surrounding mountains. During the spring season dozens of swollen streams produce turbid, tan-colored sediment plumes, which extend from stream mouths far into the lake's blue waters. Since many biological nutrients, together with tons of sediment, enter Lake Tahoe in this manner, it is important to understand Tahoe's tributary streams in both physical and chemical terms. Sixty-three streams carry water into the lake, and one of these, Ward Creek in the Ward Valley watershed, has been chosen for detailed study.

Beginning each April, warm spring temperatures melt the snowpack in Ward Valley, which is often twenty feet in depth, and the streamflow increases dramatically. Runoff reaches a maximum sometime in May, then drops rapidly during the summer dry period characteristic of the California Sierra. Heavy sediment plumes occur in conjunction with natural high stream levels in spring, as well as after summer thunderstorms and heavy fall rains that precede the winter snow.

The sediment that turns the normally clear streams opaque consists of a variety of materials, including soil particles, sand, and gravel. Under extremely heavy runoff, boulders and whole trees are undermined and toppled from the banks into the raging torrents. In addition to the visible material, the stream waters carry surprisingly large amounts of dissolved chemicals that can stimulate algal growth in the lake. Some of these enter the water on the surface, but most solution occurs when water percolates below the soil surface, where it comes into intimate contact with various living

and nonliving substances. Plant roots, fungi, bacteria, and soil animals of all sizes will interact in a series of complex chemical and physical reactions in the presence of percolating water. Eventually, much of the water comes back to the surface farther downhill and enters the stream system carrying a load of dissolved chemicals.

Ward Valley is a critical watershed within the Tahoe Basin; it was chosen for intensive study because of its size (fourth largest of sixty-three watersheds draining into the lake) and its convenient division into two upper valleys. It also allows comparisons of water quality as commercial development takes place. The small north bowl contains one ski lift and is adjacent to a major ski area. This bowl, largely under private ownership, has been zoned for skiing and housing development and may eventually support a population of several thousand residents and visitors. A potential Ward Valley boom is, of course, highly controversial in the charged Tahoe atmosphere, where developer and environmentalist are in frequent conflict. If the beautiful valley becomes a winter resort complex, the Tahoe Research Group will have collected invaluable preconstruction information for comparison with postconstruction impact on the stream-lake system.

Since 1971 we have learned important lessons about Ward Creek and its several branches. For example, Tahoe Basin streams carry large quantities of sediment into Lake Tahoe every year. Ward Creek alone accounted for approximately 1,000 tons of solids in the twelve-month "water year" ending in September, 1973. The load peaked briefly during May, when 100 tons a day-enough water and mud to send a plume more than a mile out-was carried into the lake.

Was this natural?

There are as yet few man-caused disturbances in Ward Valley. The largest quantities of sediment seem to come from the south bowl, untouched by humans in recent years, except for some logging. Therefore, we must tentatively conclude that natural erosion is currently dominant in Ward Valley. In the thousands of years before humans ever set foot in the area, natural erosion was relentlessly filling the Tahoe Basin. Glaciers ground down the surrounding granitic and volcanic mountains and may have deposited enough rocky rubble to half fill the original basin. The rocks contained few soluble nutrients, and the lake, which survived glaciation and several thousand years of stream erosion, remained in 1844-the year of Frémont's discovery-almost as sterile as the rocks in its depths.

The human impact began to be felt shortly after 1859, when, to provide mine timbers and lumber for the Comstock Lode and Virginia City, some twenty miles distant in the high desert in western Nevada, massive logging of Tahoe's vast forests began. Accelerated erosion from the denuded slopes must have been devastating to the soil, streams, and the lake itself. We have little documentation of the lake's condition after this disturbance, but bacterial and algal growth were undoubtedly greatly stimulated by the influx of sediments and dissolved nutrients. The shallow-water zones may have developed luxuriant growths of attached algae, fungi, and bacteria such as we see today around the entire periphery of the lake. This offensive green slime, called "periphyton," did not exist in the first half of the twentieth century. Did Lake Tahoe recover from man's insult in the late 1800s? We cannot yet answer this vital question, but new studies of Tahoe's recent sediment history should help us understand its capacity for recovery.

In the meantime, we do know that Tahoe is changing for the worse each year, and the Tahoe Research Group has been studying the reasons for its decline. When we speak about wastes in the lake, we mean not just sewage but any nutrient products that enter the lake at levels above their natural occurrence. One of the most important of these nutrients is dissolved nitrogen. Lake Tahoe is extremely low in nitrogen, and when, as an experiment, we added nitro-

The stalks and netlike structure of a silt particle, right, enable bacteria to cling to its surface. Once attached, the bacteria can mineralize organic matter, producing algal growth nutrients. Below: a stalked diatom, Gomphonema, forms slick surfaces on lake rocks. Photographed under scanning electron microscope.





gen in the form of nitrate, it stimulated algal growth.

The investigations in Ward Valley have revealed the principal sources of nitrate. Astonishingly, both "pure" rain and snow contain higher concentrations of nitrate than Lake Tahoe, so certainly some nitrate enters the lake as precipitation. A far more significant source, however, is the surrounding vegetation, which converts atmospheric nitrogen to nutrient nitrogen at the rate of many tons per acre per year. Most of this vast amount of potential algal nutrient is efficiently recycled within the terrestrial vegetation and does not reach the aquatic system, but such natural recycling processes can be easily interrupted or destroyed by land disturbance in the subalpine Tahoe environment. The result is greatly accelerated nitrate loss to

the lake, with consequent stimulation of growth of shallow-zone periphyton and algae throughout the lake.

In our attempts to determine the specific physical and chemical circumstances that control the balance between nutrient influx and algal growth in lake waters, we measured the biological productivity of the water in the presence of controlled additions of nitrate, as well as phosphate and other ions. Hans Paerl, a microbiologist associated with the Tahoe Research Group, also examined the particulate material in lake water samples under the scanning electron microscope. Since the electron microscope uses electrons, rather than light, and can magnify objects thousands or even millions of times, scanning electron photo-micrographs of lake organisms



show fascinating detail. Algal cells, for example, which in Lake Tahoe are mostly silicon-containing species called diatoms, appear as finely textured lacelike structures.

The biochemical studies confirmed that nitrate and phosphate are important in governing algal growth, but the microscopic studies revealed an unexpected second growth-promoting feature in the form of the sediment itself. Under the microscope, sediment particles show countless bacteria attached to their surfaces. Most of these sediment particles, both organic and mineral in nature, originate in the watersheds surrounding the lake. Somehow the particle surfaces accelerate bacterial growth in lake waters. Apparently the surfaces (regardless of their intrinsic nutrient content) are able to adsorb and concentrate nutrients from solution, allowing bacteria to use particles as "dinner plates." Scanning electron microscopy also showed that the attached bacteria can mineralize organic matter scavenged by particles. The end products of bacterial mineralization are algal growth nutrients-nitrate, ammonia, and phosphate. Thus, increased bacterial growth surfaces provided by sediment also increase the rates by which nutrients become available to other lake organisms.

Despite the growing understanding of the importance of trace nutrient ions in promoting algal growth, the general public remains surprisingly uninformed on some important characteristics of the lake. Recently, for instance, engineers and developers suggested that the lake could be used for sewage effluent disposal if wastes were pumped into the deepest waters. They reasoned that a lake as deep as Tahoe could not possibly mix to the bottom; therefore the waste could never become nutrients for algae near the surface.

One of the most interesting recent discoveries about the lake relevant to this proposal was made during the study of nitrate release from sediment particles undergoing bacterial mineralization. Approximately 80 percent of the nitrate released through mineralization originates on particles that have sunk below the algal photosynthetic growth zone, called the euphotic zone by limnologists. Lake Tahoe's euphotic zone is approximately 300 feet deep. Within this zone there is enough sunlight to sustain algal growth by photosynthesis. But nutrients deposited in dark, or aphotic, waters, extending from 300 to 1,600 feet in the middle of the lake, cannot be utilized by the algae. The question was whether these nutrients eventually become available.

To answer it, the Tahoe Research Group used nitrate concentration in the water to follow movement of water masses within the lake. In the summer, gradients of both temperature and nitrate ion build up in the lake, so that deep, cold waters contain more nitrate ion than warmer waters near the surface. During the winter months, however, the surface waters cool. By December, water temperature becomes uniform throughout the entire water column, and the lake begins to be mixed by wind action. The mixing action appears to be surprisingly complete, since we found that nitrate gradients disappeared in late winter, with the same concentration being found at all depths. From this key finding we concluded that the lake does in fact mix, and nutrients released in deep waters will be recirculated into shallower zones favorable for the growth of algae. Although the lake may not mix to the bottom every year, we now know that even in the very deepest waters of Tahoe, there is no permanent nutrient trap.

This research not only helped rule out the proposed use of the lake for waste water disposal, but also underscored the urgent need for such studies at Lake Tahoe and other natural regions under stress from urbanization. The south shore of Lake Tahoe already supports a small city, South Lake Tahoe, complete with motel rows, small businesses, sprawling residential districts, and frequent traffic jams during peak seasons, summer and winter. Adjacent to South Lake Tahoe are the Nevada gambling casinos, with their vast, treeless parking lots and high-rise building complexes that are visible from the entire basin. Incline Village on the Nevada north shore is a complete suburban community, where in a period of barely ten years, hundreds of homes and condominiums have sprung from the second-growth pine forest. Other regions in the Tahoe Basin retain a more traditional flavor-the large private estate, the small resort town, the untouched forest, stream, and meadow. But, as plans to place 12,000 residents in Ward Valley testify, the pace is quickening, and without environmental controls, there could be development around the entire periphery of Lake Tahoe and as far into the forest as a rotary snowplow can reach to rescue a stranded second-home owner.

If we cannot put a complete halt to development-which would, of course, provide the most secure future for the lake and its surrounding woodlands-then we must find workable compromises. It is within this mind-boggling arena of political debate that scientific studies can play their most significant role. By providing planning agencies with technical data and guidelines, such studies are helping to insure that the compromises will be more than hopeful gambles based on the conflicting interests of various small groups. Rather, they will reflect what is best for the survival of this remarkable lake, as well as provide perspectives on the problems surrounding all lake environments under stress from neighboring urban centers.

Monkey on a Riverbank

by Katherine M. Homewood

Adapted to a narrow, fluctuating habitat, an endangered primate depends on the instability of Kenya's Tana River for survival

The Tana is Kenya's longest river, rising from the eastern flanks of the Aberdare Range and entering the Indian Ocean more than 500 miles away. For most of its course it flows through a semidesert of scrub vegetation, but as it nears the sea and rainfall and humidity rise, groundwater seepage from the river is sufficient to support a narrow, 40-mile-long strip of patchy forest and woodland.

Here in northeastern Kenya, the river meanders across a flood plain up to five miles in width, building banks of sandy levees by continuous deposition. When seasonal rains in the catchment area around Mount Kenya are sufficiently heavy, the river overflows, flooding the plain. The swollen waters may burst through weakened banks and narrow meander loops, carving new channels and leaving cutoff levees and oxbow lakes.

The forests, which thrive best on the soil type and water conditions of the raised riverside levees, are thus subject to the vagaries of an unstable river course. As a result, the vegetation is a continually changing mosaic—areas newly exposed to colonization, young forests of a few colonizer species, mature diverse forests, and dying or degrading forests, cut off at any of these stages by a change in the river

course. The patches of forest, each no more than a few acres, are linked by stretches of woodland, bush, and grassland, which grow on soils that are poorer, less permeable, and more subject to flooding.

This is one of Kenya's richest wildlife areas. Such forest species as red duikers, waterbuck, and bushbuck are found here throughout the year. Two rare primate subspecies, the red colobus monkey (Colobus badius rufomitratus) and the Tana mangabey (Cercocebus galeritus galeritus) are found here and nowhere else.

The Tana mangabey is an attractive, hitherto little-known monkey with fawn-gray fur and a semiprehensile tail, which it carries in a characteristic questionmark pose.

Living in the small patches of gallery forest on the Tana River, the mangabey population-an estimated 500 to 1,500 individualsis some 1,000 miles distant from its nearest relatives, the subspecies C. galeritus agilis and C. galeritus chrysogaster, which inhabit the riverine forests of the Congo Basin. This curious geographic distribution of C. galeritus, together with the absence of the species from all nonriverine but otherwise apparently suitable forest, indicates that the three races are relics of a once widely spread population, now specifically dependent on gallery forest conditions.

On the Tana River, an expanding human population is progressively destroying this habitat. A two-year field study of the mangabey population was carried out in an attempt to explain their

presence in these forests and to assist in their conservation.

Various features of their morphology, ecology, and behavior appear to place the Tana mangabeys intermediate between savanna baboons and monkeys of the genus Cercopithecus, such as guenons and monas. Tana mangabeys are slightly larger than Cercopithecus monkeys and have longer muzzles with stronger dentition, but none of these traits is as marked as in baboons. Mangabeys have characteristic pads of bare skin on their rumps (ischial callosities) fused in the midline in males as in baboons. They are semiterrestrial, at home on the forest floor or 100 feet up in the tree canopy. Restricted to forest and bush, mangabeys occasionally travel through open country to get from one wooded patch to another, but not for such long distances or as regularly as baboons. Tana mangabeys live in groups of thirteen to thirty-six individualssmaller than most baboon groups-but under certain conditions groups may temporarily come together to form aggregations of fifty to sixty individuals.

Within a group there are one to six adult males and about twice as many adult females. Surplus adult and large subadult males spend comparatively little time with the group, making up a floating population of peripheral, solitary males, which spend some of their time near their group of origin, some near neighboring groups, and much of it wandering and feeding alone. This continues unless, by overpowering a resident male, they find a place in an established

group.



The ranging pattern of any one group of mangabeys depends on its habitat type. Because of the peculiar conditions dictating vegetation growth, patches of forest along the Tana River vary greatly in terms of abundance, composition, and distribution of plant species. Some forest patches contain a wide diversity of species; in others, individual plant species may be dominant over wide areas, giving a very low diversity. In the latter case, the monkeys often vary their range seasonally according to the distribution of food resources. One study group of fourteen individuals foraged over an area of some 100 acres of single-speciesdominated woodland, showing a distinct seasonal pattern in their ranging and little overlap with adjacent groups. In another diverse forest, a group of thirty-six individuals ranged over a 37-acre tract, which they shared with another group of at least twenty monkeys. Population density thus varies from less than one to more than six mangabeys per five acres. These figures, together with the total area of forest inhabited, give a total population estimate of 500 to 1,500 surviving Tana mangabeys.

The semiterrestrial mangabeys have access to a wide range of food sources; they are, in fact, highly opportunistic feeders, eating more than 100 different items from more than 50 different plant and animal species-mainly fruits, seeds, and insects, as well as leaves and flowers, bark, tree gum, and wild honey. They occasionally catch and eat small vertebrates, such as frogs and lizards, and have been observed dining on ground squirrel. Their powerful jaws and teeth enable them to strip and eat such tough items as bark and palm nuts, and their dexterity in gripping and handling small objects makes them efficient insect foragers.

The social behavior of the Tana mangabey shows certain characteristic features. At dawn, and occasionally later in the day, the adult males issue loud vocalizations audible at distances of

more than half a mile. During the dry season, this appears to be a spacing mechanism, and the groups tend to avoid each other. Occasionally an aggressive interaction occurs at a territorial boundary. Typically the adult and large subadult males of both groups advance toward the boundary, take to the canopy, and perform a series of circuits with loud calls and stiff-legged leaps from branch to branch. This display of noise and crashing foliage may develop into a chase, with a male of one group attempting to catch and bite a male of a rival group. The females and young do not participate in these relatively rare intergroup interactions. During the rainy season, however, the pattern changes. The same longrange vocalizations are given, but their spacing effect is no longer evident. Neighboring groups have several times been observed approaching each other and coming together to form temporary aggregations of fifty to sixty individuals—although intermingling between individuals of different groups is rare. This behavioral flexibility allows efficient exploitation of locally and seasonally varying food sources, so important in this shifting mosaic system.

Within the group, the adult males show a dominance hierarchy. One male may tend to be more aggressive and displace the others from choice feeding or resting positions and proximity to estrous females. Females and young are subordinate to males, and when approaching or passing a dominant male, they invariably "present" (assume a precopulatory posture) as a gesture of greeting or submission. Adult male presenting is rare but has been observed. In order to displace another male, it usually suffices for a dominant animal to simply approach a subordinate, and the latter will move away. In a more intense situation, facial expressions may be used as a threat. Eyebrows are raised and the mangabey's white eyelids exposed; the head is lowered and thrust forward, producing an effective aggressive display.

Where the dominance hierarchy is not firmly established or when a new male seeks to join the group, such threats give way to outright chasing, fighting, and bitting. A subordinate male that is being threatened may pick up an infant and hold it ventrally as a submissive display.

The leadership of the group of fourteen individuals that I studied changed three times in the course of a year—the first two times because of predation by a 15-foot-long rock python and the last time because of the advent of a peripheral male, which established his dominance over the sole remaining adult male.

As in baboons, the adult female mangabey undergoes externally visible changes in the course of her estrous cycle. At the peak of her sexual receptivity she exhibits bright pink swellings on her perineal area. In this state she is very attractive to adult, subadult, and even juvenile males. The attraction is olfactory



as well as visual—several times a male was seen approaching and sniffing a branch on which a swollen female had been sitting.

A sexually receptive female mates several times, generally with more than one male, but at the peak of her estrus, the dominant male stays close and discourages other males. The full swelling lasts for about a week and then shrinks. If the female has not conceived, she may come into estrus again. The whole cycle lasts about twenty-eight to thirty days. Birth occurs during the sixth month of pregnancy, usually between November and February, with most young born in December or January. In one study group all five adult females gave birth to healthy infants. In a second observation group containing an estimated twelve females, only four gave birth; but in this group there were a large number of young juveniles from the previous birth season. Of the nine infants born in the two groups, eight were still living when the study ended eight or more months following their births.

The newborn infant is covered with a fuzz of grayish fur; it has a bright pink face and hands and large black eyes. An infant is particularly attractive to adult and subadult females, which seek to groom and hold it. For the first couple of months, however, the mother jealously guards her offspring, and only later, when it begins to acquire the dark adult facial pigmentation, will she readily allow others to groom and hold it. By three to four months of age the infant is adventurous, spending less time with its mother, suckling less, and beginning to eat other foods by watching and copying its mother. As it matures to juvenile and subadult, peer relationships become more important, but the offspring still spends more time near its mother than with any other adult female.

When the young mangabey is between six and ten months old the mother comes into estrus again, although she still occasionally suckles her infant. Observations of known individuals and the age structure of juveniles in the group indicate that the female doesn't conceive again until about twelve months after the previous birth: the interval between births is often eighteen months to two years. Since a female takes four to five years to reach sexual maturity, this is perilously slow reproduction for an animal close to extinction.

The ecological and behavioral findings of the study demonstrate that the Tana mangabey is spe-

An ecological mosaic of forest patches, grassy fields, and bushland has been created by the unstable course of the lower Tana River. When the river changes direction, cutoff forests die because of a lack of water. Semiterrestrial Tana mangabeys, which inhabit these small forests, respond by colonizing clumps of trees in wetter areas.







A mother grooming her young removes parasites from its fur. The process also serves to reinforce the parental bond.

cifically adapted to a cyclic, fluctuating ecosystem, such as the gallery forests of the lower Tana River. Since they are semiterrestrial, the mangabeys are capable of open-country travel. They are also behaviorally equipped to visit different areas including the territories of other groups during certain seasons. In a society of long-lived, intelligent primates, this is equivalent to a capacity for exploration that leads to the colonization of newly generating stands and escape from dying forests. Population dispersal is facilitated by these physical and behavioral traits.

The mangabeys' opportunistic feeding patterns are also adaptive in an unstable ecosystem. They make use of a wide range of food sources and are physically equipped to eat tough materials. Their semiterrestriality gives them access to virtually all potential foods in the area, and because they are behaviorally adapted to travel, they can exploit distant, seasonal, and locally abundant plant species. Flexible intergroup social behavior also permits an efficient exploitation of fluctuating abundance and distribution of food sources.

Genetic diversity within the various groups may be enhanced by the mobility and sometimes rapid turnover of leading, or dominant, males, despite the potentially isolating conditions of their habitat.

These morphological, ecological, and behavioral characteristics are similar in all three of the long-isolated subspecies of C. galeritus, helping to confirm that in a seasonally flooding gallery forest system there is a selective advantage for such an adaptive complex. These rather specialized features, in many ways intermediate between savanna baboons and Cercopithecus monkeys have apparently enabled C. galeritus to survive in cyclic, fluctuating forest systems, but it may not do as well if forced to compete with more generalized primates in other, stabler environments. The Tana mangabey would be unlikely to survive should the Tana River forests be converted to a stable ecosystem. I found much evidence that this is exactly what is happening.

In many places the river banks have been cleared of natural vegetation by the Pokomo, a riverine tribe that lives by fishing and shifting cultivation. They are not hunters, but as their population steadily expands, they progressively clear more and more of the remaining forest for agriculture. They also fell trees to make dugout canoes and houses. Where large old trees are taken, a valuable and often irreplaceable structural and food element for the mangabeys is lost from

The Tana flood plain is also inhabited by the Orma, a pastoral tribe that regularly burns off grass and bush to improve the grazing for its cattle. This tends to maintain a fire climax pasture in areas where bush and woodland could have regenerated; it also damages the edges of remaining forests.

the forest.

Slash-and-burn agriculture and fire climax pastures used to be a consistent part of the dynamic mosaic of the Tana ecosystem. As the river course changed, the villages grew, shifted, and then died, to be reclaimed by forest. During the rapid population increase of the last fifty years, however, destruction has far outstripped regeneration.

In addition, the government of Kenya is implementing a scheme to harness the river for irrigation and hydroelectric power. Among other effects, this will eliminate flooding, drastically diminish the silt load, and level out the highly variable river flow to half the present average. Deprived of its cutting power, the river will be stabilized in its present course. The river regime will be converted from a fluctuating ecosystem with a continuous cycle of development and destruction to a steady one in which any surviving forests will eventually reach stable maturity.

The pattern of an ecosystem is reflected in its component species: for example, a young ecosystem favors pioneer species with prolific reproduction, efficient dispersal, wide environmental tolerance, genetic diversity, and a capacity for opportunistic exploitation. A mature system, on the other hand, has a quality rather than quantity criterion, with restricted reproduction and dispersal. Because a cyclic, fluctuating system such as the Tana's flooding riverine forests is a continuously changing mosaic of soil and water conditions, a shifting combination of pioneer and mature plant associations makes up the vegetative cover.

With control of the Tana River, all this will be changed. The colonizing plant species, with their rapid growth, short lifespan, and quick turnover of shoots, flowers, and seeds will give way to the slow-growing, low-turnover species characteristic of mature forests. Also, the reduced water supply will cause an over-all decrease in the forest vegetation. These changes will, in turn, affect the animal species. The findings of this field study indicate that the Tana River mangabey, with all its adaptations for a cyclic mosaic system, will be the one to suffer

most. Until recently, it seemed that

with the steadily encroaching human population, the Tana mangabey would become extinct very quickly. But the Kenya Game Department, together with scientists working in the area, is now organizing a small game reserve in an area of prime habitat and high mangabey density. These rare and beautiful primates and their unique habitat have been given a respite. But unless landuse practices and river management schemes are changed to preserve the Tana gallery forest ecosystem, the mangabey's future

remains in doubt.

The Hazards of Plutonium

by J. Gustave Speth

The recycling of this element—the stuff of nuclear bombs and one of the most toxic substances known—is highly controversial

The Atomic Energy Commission, if unchecked, is about to sow the seeds of a national crisis. The commission proposes to launch what it calls the "plutonium economy," which would authorize the nuclear power industry to use recycled plutonium as fuel in commercial nuclear reactors around the country. The result of such a decision would be the creation of a large civilian plutonium industry and a dramatic escalation in the risks posed by nuclear

Plutonium barely exists in nature: the entire present-day inventory is man-made, produced in nuclear reactors. Plutonium-239, the principal isotope of this element, has a half-life of 24,000 years; hence its radioactivity is undiminished within human time scales. That isotope is one of the most toxic substances known. One millionth of a gram has been shown capable of producing cancer in animals. Plutonium-239 is also the material from which nuclear weapons are made. An amount the size of a softball is enough for the production of a nuclear explosive capable of mass destruction. Scientists now widely recognize that the design and manufacture of a crude nuclear explosive is no longer a technically difficult task; the only real obstacle is the availability of plutonium itself.

We believe that the commercialization of plutonium will place an intolerable strain on our society and its institutions. Our nuclear technology has presented us with a possible new fuel that we are asked to accept because of its potential commercial value. But in our opinion, technology has outstripped our institutions, which are not prepared or suited to deal with plutonium. And those of us who have asked what changes in our institutions will be necessary to accommodate plutonium have come away from the inquiry profoundly concerned.

The AEC's recently released draft environmental impact statement assessing the effects of recycling plutonium reinforces these concerns. It concedes that the problems of plutonium toxicity and nuclear theft are far from solved and indicates that they may not be

for some years. Nevertheless, the statement concludes that we should proceed. The AEC decision, whether it stems from blind faith in the beneficence of the technology the commission has fostered or from a callous promotion of the bureaucratic and industrial interests of the nuclear power complex, cannot be justified in light of what we know and, just as important, what we do not know about the

implications of a plutonium industry.

The fuel used in today's nuclear reactors-lightwater reactors, or LWRs-is uranium that has been enriched so that its uranium-235 content is increased from 0.7 percent, the amount present in natural uranium, to about 2 to 4 percent. Uranium-235 is a fissionable isotope of uranium. The remainder of the fuel is nonfissile uranium-238. Unlike plutonium, this uranium fuel is not extremely toxic and not sufficiently rich in uranium-235 to be fashioned into nuclear weapons. When the LWRs are in operation, however, they also produce as a by-product moderate amounts of plutonium, principally plutonium-239. A typical large reactor produces about 200 to 250 kilograms of plutonium isotopes each year. Since much of this plutonium is easily fissioned, it can be used as reactor fuel. Plutonium recycle is the nuclear industry-AEC proposal to recover the fissionable plutonium produced in LWRs, process it, and recycle it as fuel back into LWRs.

Several critical steps would be involved in recycling this plutonium. First, the used, or spent, fuel from the reactor must be shipped to a fuel-reprocessing plant where the plutonium would be removed. It would then be shipped to fuel-fabricating and assembly plants for the next fuel-cycle stages. At the fabricating plants the plutonium oxide would be mixed with uranium to form fuel pellets; the pellets would be placed in fuel rods and the rods would be collected into fuel assemblies. These assemblies would then be sent to the reactors for use, thus completing the fuel cycle.

Plutonium recycle has not yet begun, and so far there is no major industrial commitment of resources

This article is adapted from "The Plutonium Decision: A Report on the Risks of Plutonium Recycle," written in September, 1974, by J. Gustave Speth and physicists Arthur R. Tamplin and Thomas B. Cochran for the Natural Resources Defense Council, Inc.

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to it. No major commercial plutonium fuel-fabricating plants are in operation or under construction, and the three nuclear-fuel-reprocessing plants that have already been built do not represent a substantial investment in national terms. They may be needed, in any case, to prepare spent fuel for long-term storage. But if the plans of the AEC and the nuclear industry are carried out, a major plutonium industry will quickly develop. Such an industry could recover some 140 tons of plutonium from commercial reactors by 1985 and 1,700 tons by the year 2000. By the turn of the century the industry could involve hundreds of LWRs fueled with plutonium, perhaps a score of fuelreprocessing and -fabricating plants, and thousands of interstate and international shipments containing hundreds of tons of plutonium.

The most pernicious product of the nuclear industry is plutonium. Microgram quantities in skin wounds cause cancer in experimental animals. Inside the body, plutonium is a bone seeker; once deposited there it can cause bone cancer. But plutonium is most dangerous when inhaled. In a recent article in the Bulletin of the Atomic Scientists, Donald Geesaman, a biophysicist formerly with the AEC and currently at the School of Public Affairs of the University of

Minnesota, explains this hazard:

Under a number of probable conditions plutonium forms aerosols of micron-sized particulates . . . if inhaled they are preferentially deposited in the deep lung tissue, where their long residence time and high alpha activity can result in a locally intense tissue exposure. The lung cancer risk associated with these radiologically unique aerosols is unknown to orders of magnitude . . . [but] under present standards, the permissible air concentrations are about one part per million billion . . . a commentary on plutonium's potential as a pollutant.

To determine the adequacy of the radiation protection standards for plutonium enforced by the AEC, two of the authors of the report from which this article was adapted, physicists Arthur R. Tamplin and Thomas B. Cochran, undertook a review of the biological evidence for the Natural Resources Defense Council. The conclusions of Tamplin and Cochran, found in their study "Radiation Standards for Hot Particles," are that insoluble plutonium particulates, or hot particles, are uniquely virulent carcinogens and that the current AEC radiation protection standards governing the amount of plutonium to which members of the public can be exposed are roughly 100,000 times too lax. The lung cancer risk associated with hot particles of plutonium, as estimated by Tamplin and Cochran, is comparable to the lethal dose of botulin toxin, a biological warfare agent. One would hope that this nation would give careful consideration to the risk involved and pursue all alternatives before implementing an energy policy based on such toxic materials.

Although the adequacy of present plutonium standards is a matter of considerable doubt and great controversy, the AEC's draft impact statement for plutonium recycle simply assumes that those standards are adequate. The entire risk analysis of the

statement, as well as the ultimate decision to proceed with plutonium recycle, is based on a premature and unexplained rejection of the hot particle hypothesis, which asserts that the intense local radiation emanating from minute hot particles is more carcinogenic than the same amount of radiation distributed over a larger tissue area. Yet despite the AEC's dismissal of this hypothesis in its impact statement, the commission concedes, in answer to a petition brought by the Natural Resources Defense Council in a separate proceeding, that the hypothesis "is being given careful consideration."

We submit that the AEC has no basis for concluding that plutonium recycle will not cause undue risk to the public health and safety until it has either satisfactorily resolved the doubts over current plutonium radiation protection standards or calculated the impacts of plutonium recycle on the assumption that hot particles are uniquely carcinogenic. The draft environmental impact statement for plutonium recycle does neither.

Some plutonium contamination of the environment has already occurred, principally as a result of the atomic weapons program. The leakage of plutonium from contaminated oil at the AEC's plutonium weapons plant at Rocky Flats, ten miles west of Denver, Colorado, in the late 1960s led to an uncontrolled source of plutonium that was much larger than the reported discharge from seventeen years of plant operation. Tens to hundreds of grams of plutonium went off site ten miles upwind from Denver.

The Nuclear Materials and Equipment Corporation, a facility in Apollo, Pennsylvania, that processes plutonium for energy research and development, was recently fined \$13,720 for a sixteencount violation of AEC regulations, ranging from failure to follow radiation monitoring procedures to failure to comply with certain safeguards requirements.

Production workers from the Nuclear Fuel Services facility in Erwin, Tennessee, which processes plutonium, met with AEC inspectors on August 13, 1974, to complain about the absence there of even the rudiments of accepted health physics practices. Occurrences such as these could multiply greatly if plutonium is made a major article of commerce.

As a fuel for power reactors, plutonium is expected to range in price from \$3,000 to \$15,000 per kilogram, roughly the equivalent of the street price of heroin. This same material might be hundreds of times more valuable to fanatics and desperadoes bent on obtaining power or wealth through the use of nuclear devices. A recent AEC study identified more than 400 incidents of international terrorism carried out by small groups during the past six years. In an age of bomb threats, aircraft hijackings, the kidnapping of diplomats, and the murder of Olympic athletes, the risks of nuclear theft, blackmail, and terrorism are not minimized even by some of the most ardent supporters of nuclear energy. Thus, Clarence Larson, former Atomic Energy Commissioner, has described the evolution of a plutonium black market:

Once special nuclear material [plutonium] is successfully stolen in small and possibly

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Once upon a time, we used to try to stuff all of our learning experiences into neat little boxes.

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Does "the screaming" cure really work?

How can income tax forms be made foolproof?

Can a chimpanzee learn to read and write?

Can criminals be rehabilitated through brainwashing? (And should they?) Can fingers see color?

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economically acceptable quantities, a supplystimulated market for such illicit material is bound to develop. And such a market can surely be expected to grow once the source of supply has been identified. As the market grows, the number and size of thefts can be expected to grow with it.

The critical point here is that these tremendous risks will become real with the advent of plutonium recycle. Black marketeers or terrorists would find it too risky to steal plutonium that has not been made easier to handle by being separated from the highly penetrating radiation in the spent fuel of present-day reactors. Until irradiated fuel is reprocessed and the plutonium separated out, the possibilities of theft in the lightwater reactor fuel cycle are accordingly minimal. But once the plutonium is reprocessed and recycled, the picture changes dramatically. Reasonable prudence, therefore, dictates that we have adequate answers to the problem of nuclear theft well in hand before plutonium recycling begins.

There is now widespread agreement, at least among those outside the nuclear industry, that present safeguards against plutonium theft are woefully inadequate. The AEC's own "Rosenbaum Report," an assessment of the adequacy of the agency's safeguards of special nuclear material made in 1974 by outside

consultants, concluded:

In recent years the factors which make safeguards [against plutonium theft] a real, imminent and vital issue have changed rapidly for the worse. Terrorist groups have increased their professional skills, intelligence networks, finances, and level of armaments throughout the world. . . . Not only do illicit nuclear weapons present a greater potential public hazard than the radiological dangers associated with power plant accidents, but . . . the relevant regulations are much less stringent.

The problem is not simply that the AEC has not implemented the necessary safeguards programs; rather the agency has not even developed an adequate

program on paper.

On the subject of safeguards, the AEC's draft impact statement for plutonium recycle breezily concedes that the objective of keeping the risk of nuclear theft small "will not be fully met . . . by current safeguards measures." Among the several steps suggested by the AEC to correct inadequacies are the following: (1) Location of reprocessing and fabricating plants next to each other in order to minimize or eliminate the shipment of plutonium between them; (2) establishment of a new federal plutonium security police force to protect facilities and shipments; (3) creation of a sophisticated security clearance system for nuclear industry personnel.

These and other proposals are still under study; their content is not yet well defined. Some would necessitate substantial changes in the structure of the United States utility industry; others might require congressional action. And the initiation of a sophisticated safeguards program would pose a threat to civil liberties and personal privacy. Nevertheless the draft impact statement recommends that we proceed now with plutonium recycle because "the Commission"

has a high degree of confidence that through implementation of some combination of [its recommended steps] the safeguards general objective . . . can be met for plutonium recycle."

The commission's faith, unfortunately, is hardly reassuring. While it may be possible to devise an adequate safeguard system in theory, there is little reason to believe that such a system would be acceptable in practice. This is true for several reasons.

First, the problem is immense. The theft of plutonium is only one type of antisocial behavior a safeguards program must protect against. Terrorist acts against the reactors, fuel-reprocessing facilities, waste repositories, and shipments of radioactive wastes could result in serious releases of radioactivity. Moreover, a safeguards system would have to exist on a vast, worldwide basis. Some 1,000 nuclear reactors are projected for the United States by the year 2000, with hundreds of shipments of radioactive materials daily. Hundreds of tons of plutonium will be in the commercial sector of our economy by that date. Abroad, American firms are constructing nuclear reactors in countries that have little political stability and in others, such as Japan, that have not signed the nonproliferation treaty. Safeguarding nuclear bomb material would ultimately require a restructuring of sociopolitical institutions on a worldwide scale. The record of the United Nations unfortunately gives us little reason to believe that this is a practical reality.

Second, safeguards are strongly opposed by the nuclear industry. The degree to which the industry is sensitive to the hazards of theft, and likely to be an effective partner in the enforcement and implementation of safeguards programs, was apparent in its vociferous opposition to the modest strengthening of AEC safeguards, which was recently

adopted.

Third, experience with present safeguards does not inspire confidence. Over several years of operation, the Nuclear Materials and Equipment Corporation was unable to account for 6 percent (100 kilograms) of the weapons-grade material it handled and, as already noted, was recently fined by the AEC, partly because of safeguards violations. At a recent safeguards symposium the director of the AEC's Office of Safeguards and Materials Management observed that "we have a long way to go to get into that happy land where one can measure scrap effluents, products, inputs, and discards to a 1 percent accuracy." This statement takes on particular significance when we realize that only 0.5 percent of the plutonium utilized by the commercial sector in the year 2000 would be enough to make hundreds of atomic bombs. The editors of the Bulletin of the Atomic Scientists have noted that the frequent misrouting of shipments of weapons-grade material highlights a key safeguards problem: hijacking. A spot check by investigators from the General Accounting Office at three AEClicensed contractors showed that in some cases access to easily portable quantities of special nuclear material could be gained in less than a minute using the simplest of tools. At two of the three plants checked, the General Accounting Office found weak physical barriers, ineffective guard patrols, ineffective alarm systems, lack of automatic detection devices, and the absence of an "action plan" should material be stolen

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It is generally recognized that a world wide campaign against the seal hunt led by the International Fund for Animal Welfare was responsible for the end of the commericial hunt in the Gulf. It is our belief that carefully regulated tours to this area could be a new source of the lost revenue and if enaugh interest is generated, the Canadian Government may establish a Marine Mammal National Park in the Gulf of the St. Lawrence.

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or diverted. In contrast, the AEC's inspectors gave the same facilities good marks in virtually every security

category.

Fourth, even if an effort is made to improve current safeguards, there is little reason to believe that the new system will operate with the virtual perfection that is essential. For example, the AEC supports the creation of a special federal police force to provide an immediate federal presence whenever the use of force may be needed to protect these incredibly dangerous materials from falling into the hands of would-be saboteurs and blackmailers. But is it plausible to believe that police would be effective at a level commensurate with the potential nuclear hazard? The New York City police department has shown itself incapable of maintaining security over confiscated heroin. Are similar losses of plutonium acceptable? The point is that our safeguards system must be essentially infallible; it must maintain what Alvin Weinberg, former director of the Oak Ridge National Laboratory, has called "unaccustomed vigilance" and "a continuing tradition of meticulous attention to detail." Yet our human institutions are far from infallible. Our experience indicates that rather than sustaining a high degree of esprit, vigilance, and meticulous attention to detail, our governmental bureaucracies instead become careless, rigid, defensive, and sometimes, corrupt. A basic question then is whether we want to entrust so demanding and unrelenting a technology as plutonium recycle to institutions that are often negligent of their own responsibilities and insensitive to the rights of others.

A final reason for believing that an adequate safeguards system would not be acceptable in practice is the tremendous social cost of such a system in terms of human freedom and privacy. Safeguards necessarily involve a large expansion of police powers. To deal with the terrorist threat, the AEC is considering surrounding us with what it calls a new "federal security system." In its draft environmental impact statement, the AEC decries court rulings "favorable to the protection of individual privacy" and calls for legislation to authorize expanded "background checks" and to create a federal plutonium police force. The plutonium police would meddle with our civil liberties on a vast scale. Surveillance would inevitably cover not only the millions seeking jobs in the plutonium economy but also those close to the job seekers and those in allied

occupations.

The commercialization of plutonium will bring with it a major escalation of the risks now associated with nuclear power—risks that many already believe to be too great. And plutonium will further strain the weakened regulatory fabric of the nuclear industry.

Hannes Alfven, Nobel Laureate in Physics, has described the regulatory imperatives applicable to the nuclear industry in an article in the *Bulletin of the*

Atomic Scientists:

Fission energy is safe only if a number of critical devices work as they should, if a number of people in key positions follow all their instructions, if there is no sabotage, no hijacking of the transports, if no reactor fuel processing plant or reprocessing plant or repository anywhere in the world is situated in a

region of riots or guerilla activity, and no revolution or war—even a "conventional one"—takes place in these regions. The enormous quantities of extremely dangerous material must not get into the hands of ignorant people or desperadoes. No acts of God can be permitted.

Writing in Science magazine, Alvin Weinberg suggests that 'what is required is a cadre that, from on, can be counted upon to understand nuclear technology, to control it, to prevent accidents, to prevent diversion" of plutonium to nonpeaceful purposes. The public and its decision makers must seriously question whether it will be possible to attract, train, and motivate the personnel required for these functions. These would have to be highly qualified persons able to maintain a tradition of "meticulous attention to detail" even when the glamorous aspects of a new technology become the commonplace operations of an established industry. We suggest that it is beyond human capability to develop such highly qualified groups generation after generation.

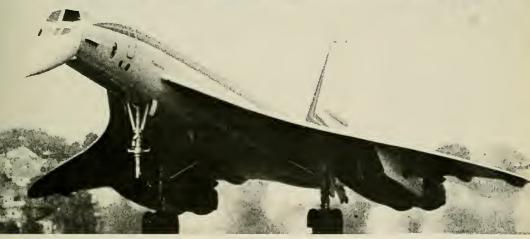
There is a sizable body of evidence at the present time to suggest that the fledgling nuclear industry is already unmanageable. Consider, for example, that 115,000 gallons of high-level radioactive wastes recently leaked from the tank at the AEC's reservation at Hanford, Washington, over a period of fifty-one days while no one monitored the tank. Radioactive releases from the Shippingport, Pennsylvania, reactor were higher than recorded. Executives of Consumers Power Corporation, a utility company in the Lake Michigan area, failed to notify the AEC that their radioactive gas holdup system was not functioning. Two reactors were half-completed before the AEC was informed that they were being constructed over an earthquake fault. The General Accounting Office found the security at plutonium storage areas totally inadequate after AEC inspectors had certified the facilities. Finally, one of the AEC's leading reactor safety experts recently quit in protest, stating that he was going to work with Ralph Nader and the Union of Concerned Scientists because the AEC has misled the public about the safety of nuclear reactors.

In view of this spotty record and considering the extreme toxicity of plutonium and the major difficulties of safeguarding it from theft, we believe that a decision at this time to proceed with plutonium recycle will escalate an already unmanageable

situation to the crisis level.

An opportunity for a review of the decision has fortuitously appeared. In October of last year, President Ford signed a bill that splits the Atomic Energy Commission into two new agencies—one to regulate the nuclear industry, the other to develop energy technologies—both nuclear and nonnuclear. Critics of the AEC, which combined both functions under one roof, had long requested the government to take that action. The new regulatory agency is the Nuclear Regulatory Commission; the new promotional authority is the Energy Research and Development Administration. We cannot urge too strongly that upon assumption of office, the heads of both agencies take an independent and searching new look at the plutonium question before we start on such a risky and irrevocable course as plutonium recycle.

Is Europe only 7 hours ahead of us?



In Britain, television watchers will soon be tuning in to an electronic newspaper, which will allow them to read the news on their television screens.

In Germany, there's a plan to place workers at the center of economic decision making by requiring that labor is represented on the boards of industrial corporations.

In Denmark, the ballet is so well subsidized that it is said the "artists and staff positively bask in tax money."
In Rumania, a doctor

has developed a drug that appears to retard aging.

In Sweden, there are no slums, no one is poverty stricken or without assistance in times of illness or accident, and everyone can look forward to a secure old age.

Quite obviously, all these countries know something we don't. The United States cannot be secure in the claim that we are foremost in social and technological progress. And the more we learn about what's being done in other countries, the more we can apply that knowledge to our own. But where do you get news of

these developments?
Rarely through our own press,

which barely has time and space to

cover domestic affairs.
You could subscribe to a lot of
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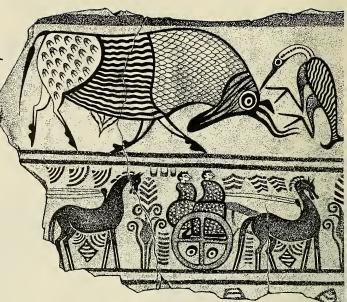
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The Evening Lecture Series for Adults

starting February 11, 1975

ARCHAEOLOGY OF THE AEGEAN SEAEight lectures on Tuesday evenings starting February 11, from 7:30-9:00 p.m. Fee: \$30

Homer's epithets, "Mycenae rich in gold" and "Crete of the hundred towns" proved accurate as archaeologists discovered the gold-laden tombs of Mycenae and the painted palaces of Crete. Plato's tale of Atlantis finds startling echoes in new excavations on Thera. A thousand years before classical Greece, the Aegean civilization with its carved gems, golden goblets, dolphin frescoes and flower-prowed ships sparkled and glowed. This series of 8 slide illustrated lectures explores the achievements of a people that step out of legend. Dr. Claireve Grandjouan is Chairman of the Classics Department at Hunter College.



Members of The American Museum are invited to participate in our unusual evening programs presented by a distinguished staff, and held at the Museum.

STUDYING ANIMAL BEHAVIOR

Eight lectures on Thursday evenings starting February 13, from 7:00-8:00 p.m. Fee: \$30.

Interest in comparative animal behavior has increased substantially, especially regarding the relevance of such studies to human society. This course illustrates the scientific philosophy and research techniques of studying species representing many levels of invertebrate and vertebrate evolutionary history. Short films on animal social behavior and environmental adaptations. Dr. Howard R. Topoff, Research Associate at the Museum, is currently doing research on development of social behavior in army ants. Dr. Ethel Tobach, Curator at the Museum and Adjunct Professor in Biology and Psychology at the City University of New York studies adjustive behavior in sea hares, rodents and monkeys.

ANIMAL LIFE IN NORTHEASTERN UNITED STATES

Eight lectures on Tuesday evenings starting February 11, from 7:00-8:30 p.m. Fee: \$30.

The New Jersey Pine Barrens, the Adirondacks of New York, and other remote areas in New England contain an exciting variety of wildlife species. These include beautiful salamanders and tree frogs, big game mammals such as moose and bear, hundreds of species of birds; a snake which is more adept at faking than the opossum. By means of color slides and recordings this series introduces these animals, and discusses where they may be found. Kenneth A. Chambers is Lecturer in Zoology at the Museum.

FOREST. WETLAND, AND DESERT: PLANTS OF NORTH AMERICA

Five lectures on Wednesday evenings starting February 19, from 7:00-8:30 p.m. Fee: \$20.

Centering on the superb exhibits in the halls of the Museum, this series of lectures examines the plants of North American wild lands. Rainforests, pine barrens, deserts, mountaintops, bogs and swamps are some of the plant communities explored. Identification and ecology of the plant is stressed. Helmut Schiller is Lecturer in Botany at the Museum.

INTRODUCING...THE AMERICAN MUSEUM!

Eight lectures on Thursday evenings starting February 13, from 7:00-8:30 p.m. Fee: \$30. Limited to 35 persons.

The exhibition halls of the Museum are world-renowned. In this series, specialized staff interpret seven major halls, using their field experiences. The final session is a "behind-the-scenes" tour normally unavailable to visitors, where future exhibit material is seen in the course of preparation. Lecturers: Malcolm Arth, Curator of Education; Kenneth A. Chambers, Lecturer in Zoology; Paul J. Sanfacon, Lecturer in Anthropology; Raymond H. de Lucia, Principal Preparator in Exhibition; Eugene S. Gaffney, Assistant Curator in Vertebrate Paleontology; Helmut W. Schiller, Lecturer in Botany; Christopher Schuberth, Lecturer in Geology.

ANTHROPOLOGY THROUGH FILMS

Six Wednesday evenings starting February 19 from 7:00-9:00 p.m. Fee: \$25.

Introducing the anthropologist's approach to culture through a series of extraordinary ethnographic films. With few exceptions, early documentaries were often technically poor with stereotyped narrations. Recently, however, some sensitive and beautifully photographed movies have resulted from collaboration between anthropologists and filmmakers. Twelve films including DEAD BIRDS, THE FEAST, INTREPID SHADOWS, NANA, MOM AND ME, THE NETSILIK ESKIMO and RIVERS OF SAND are presented by Dr. Malcolm Arth, Curator at the Museum, and include conversations with two special quests: filmmaker

Robert Gardner, Director of the Harvard University Films Study Center, and anthropologist Dr. Napoleon Chagnon of Pennsylvania State University.

NEW YORK'S PAST ONE BILLION YEARS

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Craggy peaks rising majestically skyward; aquamarine, amethyst, tourmaline, and garnet forming deep within their roots. Dinosaurs, phytosaurs, and gliding reptiles roaming about in what is today the preserve of the New Jersey commuter. Ice as thick as the Empire State Building resculpting Long Island; surging Atlantic waves throwing up familiar beaches. This is only part of the story revealed by the rock record. These slide-illustrated lectures trace the geological evolution of Metropolitan New York. Christopher J. Schuberth is Lecturer in Geology at the Museum.

AN AWAKENING IN ANTHROPOLOGY

Eight lectures on Thursday evenings starting February 13, from 7:00-8:30 p.m. Fee: \$30.

Increasingly modern anthropologists are finding new ways to study societies. Social "trivia," from naming dogs to patterns in swearing, even the choice of paints for a home, once ignored, are now considered significant social data with complex symbolic meanings. These lectures bring to light some present day thinking of anthropologists about both modern and tribal societies. Paul J. Sanfacon is lecturer in Anthropology at the Museum.

EXPLORE WEAVING

Ten lecture-demonstrations and workshops on Thursday evenings starting February 13, from 7:00-9:00 p.m. Fee: \$70. Limited to 25 persons.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon By mid-January, the sun has not appreciably changed its path across the sky from what it was on the first day of winter, and the days are still quite short, the nights long. But by mid-February, just a month later, the passing of winter is evident in the sun's motion and in the duration of daylight. The sun by then has moved halfway to the Equator from its most southerly position when winter began, and daylight has increased by about an hour and a half. Curiously, however, most of the lengthening of the day occurs at sunset. Sunrise by mid-February is only about a half-hour earlier than its latest occurrence; sunset takes place an hour later than it did in late December.

Mid-month also finds a crescent moon in the evening sky, growing to first-quarter on January 20, to full moon on January 27. Thereafter, the moon is in the morning sky—rising after sunset and remaining in the sky past sunrise. It wanes to last-quarter on Feb-

ruary 3, to new moon on February 11.

Stars and Planets Saturn is the only planet shown on the star map this month. It is in Gemini, not far from the bright twin stars, Pollux and Castor, and it appears above the eastern horizon after sundown. Saturn is brighter than either one of those stars, but there are other winter stars, higher and to the south and west of

Saturn, that are brighter than the planet.

Three other planets are in the evening sky—Jupiter, Venus, and Mercury—but all of them set too early to be included on the map. Jupiter is the only one in good position to be seen; it is low in the southwest at dusk and quite bright. Toward mid-February, however, it will set so early that it will be difficult to see. Venus and Mercury are both so low at dusk that seeing them will not be easy, although Venus will become more prominent by mid-February. The moon will be of help in finding Venus and Jupiter on February 13, when the two planets will be quite close to one another and near the crescent moon. Venus will be the brighter of the two.

In the dawn sky, you will still find Saturn visible low in the west, and Mars will be up in the southeast, rather dim, but still brighter

than the nearby stars of Sagittarius.

January 15: The moon is at apogee, farthest from earth.

January 16-17: The bright object near the crescent moon on both evenings is Jupiter, to the east (left) of the moon on the 16th, to the west (right) of the moon on the 17th.

January 23: Mercury is at its greatest distance to the left of the sun (easterly elongation) but is so low in the sky at sundown (because of its southerly position) that seeing it will be difficult.

January 25: Saturn is near the moon tonight. You will see the moon move closer to the planet until 10:00 P.M., EST, then move away from it to the east (left).

January 28: The moon is at perigee, nearest earth.

January 29: Mercury begins its retrograde (westerly) motion as it moves between the earth and the sun.

February 7–8: Mars is near the late crescent moon in the morning sky on both dates, low in the southeast at about dawn.

February 8: Mercury is between the earth and the sun.

February 11: The moon is at apogee.

February 13: Below and to the right of the crescent moon, near the horizon in the southwest, you may see Jupiter and Venus quite near one another. Venus is the brighter of the two planets.

★ Hold the star map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:20 p.m. on January 15; 9:15 p.m. on January 31; and 8:15 p.m. on February 15; but it can also be used for about an hour before and after these times.





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Letters

Pellagra's Progress

I appreciated Daphne Roe's article on the natural history of pellagra ["The Sharecropper's Plague," October, 1974]. Undoubtedly the use by aboriginal New World populations of various kinds of beans has lessened the risk of pellagra among them. However, we should consider also that maize was domesticated in the New World and has been used for food in that area about ten times as long as anywhere else. If there were any individual differences in niacin requirements, natural selection during this period may have eliminated the more pellagra-prone genotypes and left a population that was relatively tolerant of low niacin levels.

In any case where we are dealing with populations having unique dietary resources for such a long time, we should not assume that their present requirements conform to some "world

standard." The New World populations may at one time have been as susceptible to pellagra as the non-Indian populations who are now suffering from it in various parts of the world.

> ALICE M. BRUES Department of Anthropology University of Colorado

THE AUTHOR REPLIES:

The idea of susceptibility to pellagra fascinated physicians and geneticists between the years 1850 and 1920, before it was discovered that pellagra was due to a deficiency of the vitamin niacin.

In the present state of our knowledge, there is no evidence for gross differences in niacin requirements between population groups. As suggested by Professor Brues, "pellagra-prone" persons are those whose tissue stores of metabolically active derivatives of niacin are depleted because of low intake. Factors that alter nia-



cin requirements include a rare genetic disorder, drugs, and certain diseases. There is no reason to think that the prehistoric New World populations were any more susceptible to pellagra than their descendants. Since pellagra does not affect the bony structure of the body, it is impossible to prove whether or not pellagra was at one time prevalent in the New World. We only know that pellagra has been rare among Mexicans and other Central American people in the period of recorded history.

A Matter of Taste and Time

In a queasy way I can accompany Raymond Sokolov's ruminations in recent issues on cannibalism and Aztec and Trojan sacrificial rites, but part company on his recipes when I note that a leg of lamb requires three hours of turning and basting on a spit, a corn soup stew requires four hours of simmering, and baked brains require one and a half hours of boiling, simmering, and baking, not to mention several rinsings and four hours of soaking.

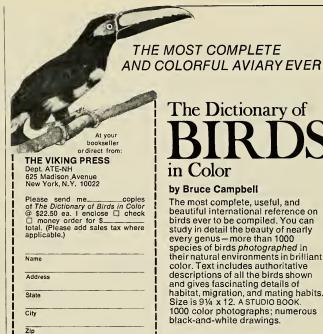
Who has the time?

ANN CRAWFORD (a retiree) Grand Cayman Island, B.W.I.

Strip Mining

Branley Allan Branson brings to light an ecological and environmental scar slashed across our country, ["Stripping the Appalachians," November, 1974], and the power companies unwittingly underline it.

A full-page advertisement in Time depicts "a tiny part of our investment in environment" by one large power company. But it only speaks to me of a bad effort to con the American public into a false sense of corporate accomplishment. A totally inept at-



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by Bruce Campbell

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and a contribution to the Museum).

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tempt at retouching the ad's photo of a wooded lake can only emphasize the degree of incompetency that marks the energy industry's "historic concern for the environment.'

> ROBERT G. RICHOLD South Plainfield, New Jersey

Powerful Wisdom

Regarding your October issue, if only more of our politicians, their economic advisors, our captains of industry, and our professors understood that which George Woodwell ["Shortcircuiting the Cheap Power Fantasy"] and Raymond Cowles ["The Flowing Well of Life"] understand!

> R. THOMAS TANNER Randle, Washington

Metric Muddle

Allow me to sound a reactionary note against the metric system. I favor continuation of our present chaotic English measures for reasons of simple, Piagetian psychology: no one can customarily conceptualize the use of two different measurement units simultaneously.

To wit, the following statements are virtually incomprehensible: "It is approximately 16 million feet from Los Angeles to New York." "Measure me off one-hecadrillionth light-year of that chartreuse dacron."

Furthermore, the greater part of metric applications fall into discrete socioeconomic ranges. No one expresses the volume of a civic swimming pool in cubic centimeters, for example; and botanists are the only group I could name offhand who employ, if only in reference books, the very rare decimeter (for heights of low plants).

In my opinion, conversion from one distinct system to another is so unusual and difficult as not to warrant the effort of switching to the Napoleonic conformity of a metric system for mundane measures.

One is reminded of the old gent in George Orwell's 1984 who complained bitterly that he couldn't get a mere pint of beeronly a liter (too much) or a halfliter (too little).

> DAVE OSHEL Ames, Iowa

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Natural Enemies in Place of Poisons

BIOLOGICAL CONTROL BY NATU-RAL ENEMIES, by Paul DeBach. Cambridge University Press, \$14.95; paperback, \$5.95; 323 pp.,

Charles Darwin noted that populations of organisms are regulated by what he called the "hostile forces of nature": predators, parasites, diseases, climate, weather, and food shortages. When a population rises to a level that causes humans to regard it as pestiferous, the reason is usually that food is so bountiful and weather and climate so benevolent that the effects of predators, parasites, and pathogens become-from our viewpoint-insufficient. Sometimes we cause such situations by providing potential pests with an abundance of food plants or animals or by transporting a potential pest (like the European corn borer) to a new locale without transporting its predators, parasites, and pathogens. Or else we provide food where the climate and weather favor the pest but do not favor its parasites, predators, and pathogens.

Changing the effects of climate and weather on the pest (for example, planting corn later) is usually called cultural control; changing the effects of parasites, predators, and pathogens is called biological control, which is the main subject of DeBach's book. There are two principal methods: importing enemies that attack the same or related organisms elsewhere and assisting existing enemies by cultural or

other means. DeBach has written what I'd call a biological adventure book; one that probably should be read by every person who has something to say about the distribution of funds for biological research. He begins by explaining how pests can be fostered through the misuse of chemicals and how difficult it is to know how much control is being accomplished by their natural enemies. Then he recounts the some-

times magnificent adventures of early explorers for useful parasites and predators and describes a whole series of early and modern efforts at biological controlcases that most people have forgotten because they worked. When chemical control is successful you remember because you have to know what to buy and how to apply it next time; with biological control you forget because there is no next time.

Finally DeBach considers how to maximize biological control through research, how the public can utilize biological control, related methods of using resistant plants and altering cultural practices, and how to escape the pes-

ticide dilemma.

Most pests are insects, and so are most of their enemies; so biological control is largely the domain of entomologists. DeBach is an entomologist, and so am I, and both of us were intrigued early in our careers by lectures we heard on biological control: in his case by Harry Smith and in mine by Alvah Peterson. DeBach followed his early inclinations and became a biological control expert. I did not. Nor did any of my fellow students at Ohio State University, and I have often wondered why.

One reason is that we were not living in California. In this book DeBach tells us that Hawaii and California have long been the strongholds of biological control in the United States, partly, I suspect, because they are in a sense both islands (California, in regard to its citrus industry), so their pest problems have a contained aspect that may have kept people convinced of the efficacy of biological control methods.

Another reason is that biological control was literally being smothered during the 1950s by the advent of family after family of chemical pesticides. Students in Alvah Peterson's biological control class openly spoke of him as old-fashioned, and most of them thought that biological control was a pipe dream of prepesticide days. Chemical control in the 1950s was decidedly newfashioned, as well as quick and effective. No one even mentioned pollution in those days, and if a new chemical was unusually potent, it was merely viewed as part of the excitement of technology. After all, to live in these complex times, one had to know enough not to step in front of traffic and such things; proper use of deadly poisons was just another part of the game.

There is no way the influence of chemical pesticide companies on entomology departments during my graduate-student days can be overemphasized. National entomology meetings sometimes seemed like one long series of hospitality suites rented by the pesticide people, and I remember having the same feeling about them that I developed about the poolroom in my little home town-a place where, if you went, you'd probably enjoy it, but down deep in your soul you knew it was having an evil effect. Anyone who wondered why there were no large audiences listening to the papers (the presentation of which provided at least the academic speakers with funds to attend the meetings) didn't understand the lure of those hospitality suites and the free liquor served there.

More insidious, perhaps, were the votes cast by hordes of direct and indirect representatives of the pesticide companies who filled the meeting halls. I doubt that a pesticide representative ever had difficulty obtaining funds to travel to an entomological meeting. I will never forget sitting absentmindedly in the general session of the meeting of the Entomological Society of America in Philadelphia, lazily looking over my program for the most valuable session to attend and suddenly realizing to my horror that a resolution to censure a journal, its editor, and an author had just been offered and accepted almost unanimously without significant debate. The

by Richard D. Alexander

stated reason for this churchlike antiheretical behavior was that the author had said some things reflecting on economic entomologists. In fact he had written an antipesticide article.

Scientific societies are usually not exclusive; anyone interested in the organisms or problems involved can join. As a result, some societies become top-heavy with sentimental amateurs, others with crackpot splinter groups of various sorts. The entomologists were simply overwhelmed by chemical

pesticide interests.

The critical question is why chemical insecticides swamped biological control two or three decades ago. Most people probably believe that it was because they are cheaper, quicker, and more effective. I have also heard biologists say that it is because so much specialized and complex information is needed for effective biological control. Anyone who believes these things hasn't considered the enormous amount of money, manpower, and knowledge poured into chemical insecticides. DeBach says that it now costs at least \$4,000,000 to research, develop, and market one new pesticide, whereas he recently discovered and imported two effective new parasites for less than \$500, and some others have cost less than \$100 each.

So there must be another, more powerful reason. I think it is simply that biological control generally does not involve products on which profits can be made, while chemical control does. Involve a product and a potential profit and American initiative will take over. Biological control not only does not entail a product, it requires massive government involvement. As a result, until such time as substituting biological for chemical control becomes clearly vital to the national security, the requirements for its implementation come very close to being considered downright un-American. Indeed, as DeBach notes, antipesticide people are commonly accused of being against free



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enterprise. Paradoxical, isn't it?

In Hawaii the sugarcane planters were sufficiently few, powerful, and farsighted to get together and fund exploration for effective parasites before pesticides became available; they formed a parallel to the governmental action that will be necessary in most cases. In the case of the bacterial milky disease of the Japanese beetle, a product is involved: packets of bacterial preparations can be purchased and applied by the ordinary customer. Unfortunately, as DeBach notes, pathogens are not ordinarily highly effective control agents because they spread only when pest densities are higher than considered acceptable.

This book is full of good, solid facts, often so contrary to general impressions or the common intuition that one wants to start a "false impressions" game of the sort seen in family magazines. For example: (1) Most insects are pests. False. Fewer than 1 percent can be so classified and, just for openers, every one of them has several or many (DeBach says up to 100) known enemies, all of which are by definition beneficial. (2) Biological control hardly ever works. False. It nearly always works. That's why fewer than 1 percent of the insects are pests, and it's why the ecologists are always wondering what accounts for the widespread stability of natural populations. If they ever found out, we'd be much closer to success in biological manipulation of the few that do expand sufficiently to become pests.

It strikes me that the entomologists studying biological control are on some kind of remarkably convergent path with the general theoretical and experimental ecologists, and the sooner they get together, the better. (If the entomologists get there first, it won't be novel; they've already done it with the study of social life.) As DeBach points out, the best demonstrations of the effects of between-species competition are probably found in the field experiments performed during biological control efforts. Biological control experts are discovering some significant effects of species diversity, another pet problem of ecologists.

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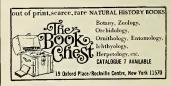


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Despite my fair knowledge of, and respect for, biological control, some items in this book brought me up short. I always thought that the control of the coconut leaf-mining beetle in the Fiji Islands, effected by first drawing up a list of the required attributes and then seeking a parasite species that matched it, was a classic in how to proceed. But DeBach notes that it's better to import several parasites, even if they compete, than to rely upon one. It makes sense. The approach is simpler and cheaper (you don't have to determine beforehand which one will be best), several parasites may compensate for one another's weaknesses, and over the long term their competition is likely to improve their effects as a result of natural selection. And "long term," despite efforts to distinguish ecological and evolutionary time, may be no more than a few generations.

I was also astonished to discover that "an analysis of all worldwide importation projects prior to 1970 shows that some significant degree of success has been achieved with about 54% of all target pest species . . . substantial or complete success . . .

with about 40%.

Despite its obvious intellectual attractiveness, I doubt that young Ph.D.'s will be much more encouraged today than I was eighteen years ago to believe that biological control is a lucrative field. DeBach gives figures on the direction of entomological research within entomology departments: "The majority of state universities or their experiment stations in the United States have departments of entomology but only a handful have even one man specializing in biological control research . . . all receive unsolicited donations for research principally from chemical companies." He goes on to note that "one of the largest departments (including the largest biological control research group) [received in donations] in . . . 1969 and 1970, \$8,536.91 . . . for biological control research . . . \$494,188.77 . . . for other entomological control research, predominantly on chemical pesticides."

DeBach doesn't flinch from placing the blame: "As long as we ignore, anywhere in the world, an effective natural enemy capable of controlling one of our major pests, we are postponing cheap, reliable and permanent control . . . yet we continue to do this with 95% of the world's insect pests. The cost of other treatments and crop loss in the interim may justly be charged against the entomological profes-

He is being more harsh than I would be. I want to spread the blame to include the voters, legislators, and academicians who ought to take a look at this book. I want especially to include among the academicians those of my fellow biologists who, when asked about worthy major projects by the National Science Foundation, continue to deny the need for anything like a federally supported biological survey or cadre of career researchers, studying the biology of (particularly) the thousands of insect groups, unknown but potentially important, scientifically orphaned, and doomed to remain so.

I have never forgotten reading in the *Reader's Digest* in the 1940s that insect pests would soon be no longer: DDT would eradicate them all. Nor can I forget my dairy farmer grandfather asking me earnestly ten years later (when I was a new Ph.D. in entomology) why insecticides no longer affected the flies in his barn. I should have replied, "Evolution, Grandpa, the same thing that keeps biological control working all by itself."

It is a tribute to our ecological ignorance that we have never purposely annihilated a single entire pest species anywhere by any means; nor have we clearly saved a single endangered species that we were annihilating accidentally or incidentally by our presence or activities. This doesn't say much for our potential ability either to keep our own species from becoming dangerously pestiferous or to prevent it from annihilating itself accidentally. One thing needed is more Paul DeBachs, and more books like this one.

Richard D. Alexander is professor of zoology and curator of insects at the Museum of Zoology, The University of Michigan.

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The Melting Pot

When cultures blend, the resultant cuisine may be a delicious international stew

The restaurant at Grand Santi, a small village on the banks of the Maroni River in the interior of French Guiana, will probably never win any gastronomic awards. One ugly, fly-filled room with a packed-dirt floor, it has no menu and serves whatever the owner can find for his wife to cook. Pot luck at the edge of the world's largest tropical forest can mean a ragout of peccary, spider monkey en civet, fricassee of flamingo, or piranha meunière. The raw materials are not merely exotic in themselves; they are also prepared with an unusual combination of French technique and tropical taste and verve. That is true, at least, of some dishes. Others are a combination of tropical technique and French taste. For lack of a better word, the mixture is known as Creole.

We have our own celebrated example of Creole food in New Orleans, where the cuisines of France (mostly Marseilles), West Africa, the local Indians (who contributed sassafras, called filé, as a thickener for gumbo), and Italy have profitably collided. However dismal the history and the political realities of this joining may have been for the individual groups, no one would argue that crawfish etouffé has been anything but a pan-ethnic boon; that is, perhaps, no one but an articulate crawfish about to be devoured, along with thousands of his congeners, at one of the seasonal gorges in the Louisiana hurricane country.

Louisiana was foolishly abandoned by the French long ago, but they held on to Guiana, as well as Martinique and Guadeloupe, and made them each fulledged departments of the "mother country." Prolonged French influence in the islands

has allowed a Gallo-Caribbean cuisine to flourish and to attain the highest levels of culinary ingenuity. In some instances, however, Creole food is mixed up so bizarrely that a factual description of a recipe almost sounds like an international joke.

At Grand Santi, being of stout palate, I had just polished off the peccary stew (which turned out to be delicious, a bit like young wild boar), when two fishermen came in with a cayman, the al-

ligator of the region.

Now I really should have expected to see a cayman in Guiana, even to be served one. I had, after all, read André Nègre's classic and intelligent cookbook, Les Antilles et la Guyane à travers leur cuisine, and was passively aware that the fleshy tail of the cayman is smoked and enthusiastically eaten in Guiana. According to Nègre, "the medallions of this long appendage make excellent meat, white and dense like saddle of roast rabbit." (He adds: "It goes without saying that it is preferable to remove the skin, because the scales, which are ideal for handbags, shoes and belts, do nothing for cayman à l'armoricaine, no matter how long you simmer them.")

All the same, I must confess to having felt a tremor or two as the beast's eyes shone among the flashlights pointed at him. We were sitting with the lights off because Grand Santi has a 9:00 P.M. curfew. Our host, the innkeeper, was attempting, in a combination of broken English and French, to explain how he left his native Saint Lucia and ended up in a remote settlement of ethnic West Africans whose ancestors ran away from slavery in Surinam (across the Maroni River) and reestablished their tribal life on the river's French-run east bank. The Saint Lucian saw himself as a representative of civilization among the savage Bonis, who have preserved their animism, their political life, their matrilineal-matrilocal kinship system, and their intricately symbolic tradition of semiabstract art despite more than two centuries of contact with missionaries, money, and white hegemony.

That same week (although at the time we didn't know it) two black American scholars surfaced in the North American mass media to announce that they had found the cultural origins of negritude among the Surinamian Djukas, a tribe almost identical in history and custom to the Bonis. This claim would probably be disputed by the leading ethnographer of the Maroni, Jean Hurault (Africains de Guyane), who has argued in great detail that the art of these black refugees is original and does not imitate known African traditions.

Such rarefied questions did not, however, come up that night in Grand Santi. Instead, two flesh-and-blood Bonis were presenting us with a very contemporary cayman hooked only minutes before from a dugout that had a geometric, Frank Stellaesque vagina painted on its transom. The Saint Lucian was

very pleased.

What did our host have in mind for his windfall lizard? Would he smoke the tail or stew it? No, he was going to marinate the cayman's tail and broil it, en brochette, with slices of merguez, the hot Algerian sausage. This was going to be Creole cooking with a vengeance, culinary Dada. In a South American village inhabited by culturally independent West African citizens of France, a Saint Lucian was about to combine a cayman tail steeped in peppery Creole marinade with an imported North African sausage and cook them in the manner of the Levant. Or was his inspiration Indonesian? He might have picked up the idea of brochettes from the Saturday night satés sold in the streets of nearby Saint Laurent by an Indonesian girl, who also made a fiery condiment from peanuts and called it sauce pistache.

No matter. The jangle of cultures was too loud in that darkened room for anyone to sort out all the discordant culinary notes. But it was definitely clear that the concoction in question was an exaggerated example of the nature of all Creole food, which is the native kitchen's response to colonialism. Without slavery, the Boni fishermen would have been baiting hooks in Senegal instead of exercising French citizenship with a vote for Giscard. Without imperialism, the hotelier would also be in Africa, not despising other Africans, untutored in the art of Franco-Arabic cookery. Without the continuing French interest in Guiana and North Africa, no shipper would be sending merguez halfway round the world.

But, from a purely gastronomic or should I say ethnogastronomic point of view, is this bad? Isn't it really a positive thing for Creole peoples that their nutritional life has been enriched by foreign food ideas? Indeed, we might even go so far as to say that it is the European cuisine that has been enhanced by an influx of new raw materials, methods, and spices from the Third World.

Parisians eat merguez in their homes. Bananas are flamed in the restaurants of Cannes. At the table, it is hard to tell who is

colonizing whom.

This same ambiguity pervades the entire Creole cuisine. Some recipes are clearly the result of a European method applied to an ingredient of the Caribbean. Christophine soufflé is just one example (the christophine, or chayote, Sechium edule, is a squashlike vegetable). Plantains à la Béchamel is another.

On the other hand, it is just as easy to locate Creole dishes that give European ingredients or food ideas an Antillean identity. The bland boudin noir ("blood sausage") of France is utterly transformed by the addition of those pale but powerful little hot peppers of the islands. The same is true of salt cod served in a sauce of oil, parsley, onion, hot pepper, and garlic, colored red with the seeds of the roucou tree (Bixa orellana, also called annatto and achiote).

Finally, of course, there are also dishes that are mainly local: the various migans (preparations of diced, stewed vegetables) and the venerable Martinican specialty, a soup called patte-en-pot ("paw in pot")—an imposing combination of lamb innards and feet, spices, potatoes, turnips, carrots, cabbage, celery, leeks, onions, pumpkin, and yams.

Admittedly, some of the ingredients in this banquet dish were originally European, but the dish itself is a product of the fertile imaginations of Martinican cooks. The same should really be said of the Creole cuisine as a whole: it is not, despite many borrowings, a hybrid so much as a new species. The marriage of French and Caribbean cooking took place many years ago under duress, but now we are faced with the irreversible fact of a new and separate cuisine that is, happily, successful and flourishing. Perhaps we should now abandon



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the term Creole in favor of Antillean or Guianese.

Migan de Figues Vertes

4 green plantains*

Salt 10 tablespoons oil, approximately l bunch scallions, trimmed and

chopped 1 tablespoon chopped chives Pepper to taste

Sliced Caribbean hot pepper* or crumbled dried chili or red pepper flakes to taste

1 medium onion, thinly sliced

2 tablespoons butter pounded to a paste in a mortar with

2 teaspoons annatto* (sold under the Spanish name, achiote)

1. Peel and dice the plantains and cook in boiling, lightly salted water until tender. Purée with a potato ricer.

2. Heat 8 tablespoons (1/2 cup) of the oil in a skillet. Add scallions, chives, pepper, hot pepper (or dried chili or red pepper flakes), and salt. Sauté until the scallions just begin to brown. Then stir in the plantain purée (add additional oil, if necessary, to produce a smooth texture), cover, and simmer over low heat for five minutes.

3. Meanwhile, heat the remaining two tablespoons of oil in another skillet. Lower heat, add the onion slices and sauté until translucent. Then add one sliced hot pepper (or 1 crumbled chili or a small amount of red pepper flakes) and the annatto butter. Mix well to make a sauce.

4. Mound the completed purée on a serving platter, pour the sauce over it, and serve hot.

Yield: Eight servings

If you combine this dish with pork, you will have the Guadeloupe dish celebrated in André Schwarz-Bart's novel Un plat de porc aux bananes vertes. The name of the recipe comes from an old name for plantain, figuier d'Adam, or Adam's fig tree, so called because a plantain leaf is large enough to do a fig leaf's

*Available in Hispanic markets in the United States.

Raymond Sokolov is a free-lance writer and food columnist.

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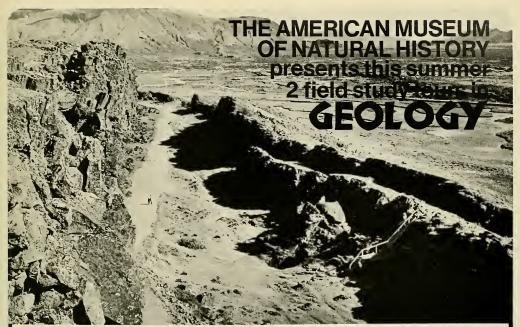
In Gallery 77 of The American Museum of Natural History, "Puppets: Dance and Drama of the Orient" continues through April 20. This extensive and ancient collection of puppets and puppet theater from China, Japan, India, Thailand, Indonesia, and Malaysia dates back 2,000 years. The exhibit includes hand, rod, and string puppets; masks, scenery, and musical instruments; and films of puppet performances in subtle images of colored silhouettes. On Wednesday and Sunday afternoons from 1:00 to 4:00 P.M. two puppeteers give live demonstrations on how the puppets work. Continuous puppet films are shown daily: Awaji, from Japanese folk tales; Nang Yai, the only puppet group left from northern Thailand; and shadow, rod, and marionette puppets from the People's Republic of China.

Museum Fragrances may be enjoyed at all times in various exhibit halls: aromas of grasslands in the Man in Africa Hall; dry hay fields in the Asiatic Mammals Hall; frangipani and salt air breezes in the Peoples of the Pacific Hall; and conifers, earth, ferns, dried and decaying leaves pervade the North American Forests Hall.

The following Films will be shown at 2:00 P.M. in the Museum's Auditorium. January 8: Nature's Half Acre, on the seasonal life of North American animals and plants, will be shown with Bear Country, about the life and habits of the American black bear. January 11: Birth of the Red Kangaroo, which deals with this Australian marsupial, and a repeat of Bear Country will be the features. January 15 and 18: Birch Canoe Builder depicts the building of traditional Indian canoes by a midwest naturalist, and The Last Stand portrays timber and forestry practices in the Pacific Northwest. January 22 and 25: Life in a Garden, is a film on suburban wildlife, and Water Birds is about the habits and environments of these birds. January 29: Angotee, depicting the life of a Canadian Arctic Eskimo, and Tununeremuit, featuring the evacuation (due to atomic tests) of Alaskan Eskimo, will be screened.

On January 7, a new Sky Show opens at the Hayden Planetarium—American Museum. "Sol" explores the relationship of life on earth to solar energy, as well as the place of the sun in the galaxy. The show runs through March 3.

Sky shows begin at 2:00 P.M. and 3:30 P.M. during the week, with more frequent showings on weekends. Admission is \$1.75 for adults, and \$1.00 for children.



Thingvellir, where the stretching, widening, and tearing rift of the Atlantic sea floor is evident on the Icelandic mainland. Here, in 930 A.D., the ancient Icelandic Parliament, the Althing, was founded some 30 miles from the capital city of Reykjavík on the southwest coast.

A Geologic Tour of Iceland August 13 to August 28, 1975

Rising above the North Atlantic Ocean, Iceland lies atop the Mid-Atlantic Ridge, a separating sea-floor rift. A continuous history of volcanic activity along this submarine fracture developed the island some 15 million years ago. Glacial ice also has shared in shaping the island. Iceland, a land of fire and ice, is one vast natural outdoor laboratory. It stands today as a focal point in the new geology of plate tectonics. Its modern landscape, pristinely clean, uncrowded, and unpolluted, continues to be profoundly reshaped by these primeval geologic forces. As a comprehensive program, this study tour will circle the island by road, with short hikes into less accessible regions.

An East African Geological Safari July 24 to August 13, 1975

Kilimanjaro; Olduvai Gorge; Rift Valley; the Serengeti. All are particularly well known features of East Africa. During this in-depth field study program,

these, as well as other areas of geologic interest in Kenya and Tanzania, will be visited. Opportunities to collect fine mineral, crystal, and fossil specimens are provided. In the great game reserves—Amboseli, Ngorongoro, Tsavo, the Mara—the horizon-to-horizon herds of wildebeest and zebra in migration, prides of lion and herds of elephant, or the solitary cheetah, leopard, and rhinoceros, will be captured on film. On safari, the peoples of East Africa, especially the Masai and Kikuyu, will become familiar companions.

Both programs arranged and directed by Christopher J. Schuberth, Lecturer in Geology at the Museum. For further information and detailed descriptive brochures, write or telephone immediately:

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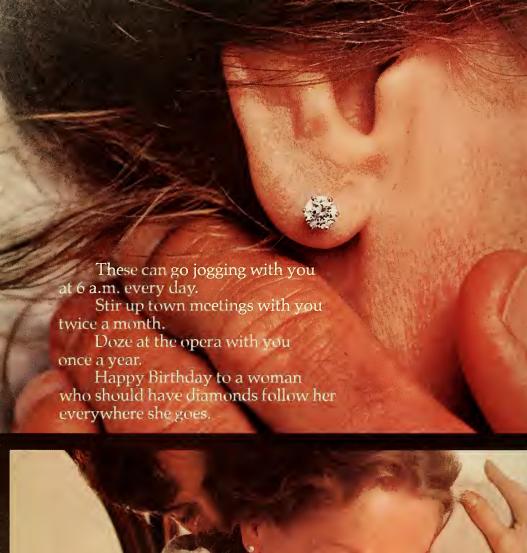
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Cover: In a headdress of evergreen boughs, a young Santa Clara Indian prepares to celebrate the deer dance. Photograph by John Running. Story on page 38.

Authors

A law enforcement officer's request six years ago for assistance in identifying a bag of rocks aroused geologist Raymond C. Murray's curiosity about the use of geologic evidence in criminal investigations. His field work on the characteristics of different geologic formations has taken him to such diverse places as Holland, the Netherlands Antilles, and the Persian Gulf. Murray is chairman of the Department of Geology at Rutgers University in New Jersey and the author of one of the first books to deal with the subject of forensic geology. His article on the formation of salt beds appeared in the October, 1971, issue of Natural History.





Like many Indians who have left their home towns for cities, N. Scott Momaday, shown here with his father, A. M. Momaday, returns each year to participate in traditional dance ceremonies. Momaday, a Kiowa, was born in Oklahoma and now lives in Cali-

fornia where he is professor of English and comparative literature at Stanford University. He is the author of House Made of Dawn, which won the Pulitzer for fiction in 1969; The Way to Rainy Mountain; and Angle of Geese and Other Poems.

John R.G. Turner's interest in butterflies began when, as a child, he sorted out the collection of his grammar school in his native England. As his interest blossomed, he went on to study butterflies and moths in Great Britain, Trinidad, Surinam, and Panama. Turner has concentrated his studies on the genetics of species formation and the adaptive mimetic strategies of the genus Heliconius. He is currently pre-paring distribution maps of the varied species of Heliconius based on data in European and American museums, and he has begun a captive breeding program to investigate the genetics of the color patterns in these butterflies. Turner teaches ecology and evolution at the State University of New York at Stony Brook.



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Faced with 800 unidentified puppets from India, 16 from Thailand, and several thousand dismembered Chinese shadow figures, **Bettie Erda** began five

years ago to catalog The American Museum's Asian theatrical collection. This project developed into a study of the figures' iconography, which required visits to the Hermitage museum in Leningrad and to the 1970 Congress of Chinese Scholars in Stockholm. At the same time, Erda was also preparing the Museum's current exhibit of "Puppets: Dance and Drama of the Orient." Working with Erda was Jo Humphrey, whose experience with Chinese opera repertory enabled her to assemble the casts of the shadow plays, thus making possible the animation of "The Chaos Box."



Dennis Puleston left his native England in 1931 aboard a 30-foot yawl. Six years later he reached China and then, by land, he reversed the odyssey to return home. After World War II he emigrated to the United States and eventually became the director of technical information at the Brookhaven National Laboratory on Long Island. Now retired, Puleston is the founding chair-

man of the Environmental Defense Fund, which was established in 1967. Since the 1940s, he has closely followed the fortunes of Long Island's ospreys and has studied their reproductive success throughout the northeast. His other research interest is the migration patterns of small passerine birds, a project for which he maintains a banding station near his home.



"I have been interested in living fossils ever since I was in graduate school," says paleontologist Niles Eldredge, who has studied the evolutionary history of trilobites, horseshoe crabs, and their kin. An assistant curator of invertebrate paleontology at The American Museum of Natural History, Eldredge is also adjunct professor of biology at the City University of New York and adjunct assistant professor of geology at Columbia University. His first article for Natural History, "A Trilobite Odyssey," appeared in the December, 1972, issue. Eldredge's future plans include investigating the Devonian trilobites of Brazil, the Falkland Islands, and South Africa.

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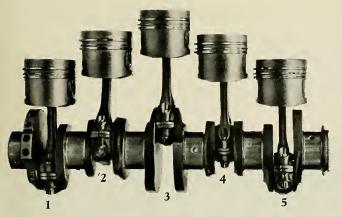
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Letters

Complexities of Extinction

Stephen Jay Gould's review [Natural History, October, 1974] of a popular hypothesis about the causes of ancient mass extinctions of organisms is persuasive. This hypothesis supposes that the drift of plates of the earth's crust provided the conditions for significant drop in sea level, the draining of the epicontinental seas, and consequent reduction of a specialized habitat. This promising idea is under intensive investigation by many paleontologists.

I am not so sanguine, however. I do not agree with Gould that the oldest and deepest dilemma of paleontologists "has been resolved" by recent work of Schopf and Simberloff or that plate tectonics holds "the key to understanding mass extinctions in general."

Questions not yet answerable by the plate tectonics hypothesis of mass extinctions include:

1. While sophisticated puter analysis shows a correlation between area of marine strata of the epicontinental seas and the diversity of their fossils, this method does not add significant new information about facts or causality. Skillful quantification of imperfect raw data encourages confidence in conclusions that may or may not be warranted by the evidence. The distribution of the old seaways is inferred from the known distribution of the sedimentary record. This approach contains several probable sources of error in estimating habitat areas. The regional maps that have been constructed do not differentiate areas of the seas that were abnormal with respect to salinity or other conditions that would render them more or less uninhabitable.

2. The hypothetical relationship between plate movements and eustatic oscillations of sea level is uncertain.

3. For terrestrial organisms, the over-all effect of shoreline shifts probably would be climatic changes, but these changes are unknown and untested. Broadly viewed, the extinction of the paleophytic flora at the end of the Paleozoic suggests some kind of climatic episode, but this is not understood. I favor the mechanism of progressive habitat loss as a probable contributory factor in mass extinctions and I have repeatedly cited this factor in publications. However, the Cretaceous-Paleocene evidence, which I summarized in 1972, links the extinction of temperature-sensitive reef biota with dinosaurs, globogerines, anmonites, and benthonic bivalves in a single grand episode that must have involved much more than a simple retreat of the epicontinental seas. The emerging picture, although confused, indicates complex rather than simple causes.

4. Mass extinctions evidently did not occur at precisely the times of maximum withdrawal of the shallow seas from the continents. Over vast areas in North America and southern Asia the evidence of broad withdrawal of the seas is an inference derived from fossils—paraconformities. The rocks, on the other hand, say that these areas may not have been exposed to the air until after the lower Triassic. How else can we explain the lack of physical evidence of hiatus?

These complications suggest to me that shrinkage of the epicontinental seas at various times in the past was important but was only one of several factors involved in the mass extinctions. Probably each episode was unique in some respects.

> NORMAN D. NEWELL The American Museum

DR. GOULD REPLIES:

I wish I had been in the position to make and defend a statement so sweeping and comprehensive as that imputed to me by Newell; my article, in fact, made a much more modest claim-that the Permian extinction (not all mass extinctions) was caused by some set of consequences (not just reduction in the area of shallow seas) associated with the suturing of all continents into a single Pangaea. I emphasized Schopf and Simberloff's work because it both integrates a theory of modern ecology with events in the past and presents a quantitative claim that can be tested. As I wrote: "Area alone is not the whole answer. Such a momentous event as the fusion of a single supercontinent must have entailed other consequences detrimental to the pre-Permian ecosystem." Thus I applaud Newell's emphasis on climate to explain the related extinctions of terrestrial floras. And, of course, I endorse his elegant work of more than 20 years on the importance of reduction in area as a cause of extinction. I merely suggest that plate tectonics can tell us why the area of shallow seas was so severely reduced in the late Permian.

Human Values

Since Natural History usually avoids political controversy, Peter Beard in his review of The Last Continued on page 82



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Like the semipermeable sheath of a cell, the earth's atmosphere transacts exchanges essential to life

Viewed from the distance of the moon, the astonishing thing about the earth, catching the breath, is that it is alive. Photographs show the dry, pounded surface of the moon in the foreground, dead as an old bone. Aloft, floating free beneath the moist, gleaming membrane of bright blue sky, is the rising earth, the only exuberant thing in this part of the cosmos. If you could look long enough, you would see the swirling of the great drifts of white cloud, covering and uncovering the halfhidden masses of land. If you had been looking for a very long, geologic time, you could have seen the continents themselves in motion, drifting apart on their crustal plates, held afloat by the fire beneath. The earth has the organized, self-contained look of a live creature, full of information, marvelously skilled in handling the sun.

It takes a membrane to make sense out of disorder in biology. You have to be able to catch energy and hold it, storing precisely the needed amount and releasing it in measured shares. A cell does this, and so do the organelles inside. Each assemblage is poised in the flow of solar energy, tapping off energy from metabolic surrogates of the sun. To stay alive, you have to be able to hold out against equilibrium, maintain imbalance, bank against entropy, and in our kind of world, you can only transact this business with membranes.

When the earth came alive it began constructing its own membrane, for the general purpose of editing the sun. Originally, in the time of prebiotic elaboration of peptides and nucleotides from inorganic ingredients in the water on the earth, there was nothing to shield out ultraviolet radiation except the water itself. The first thin atmosphere came entirely from the degassing of the earth as it cooled, and there was only a vanishingly small trace of oxygen in it. Theoretically, there could have been some production of oxygen by photodissociation of water vapor in ultraviolet light, but not much. This process would have been self-limiting, since the wavelengths needed for photolysis are the very ones screened out selectively by oxygen; the production of oxygen would have been cut off almost as soon as it occurred.

The formation of oxygen had to await the emergence of photosynthetic cells, and these were required to live in an environment with sufficient visible light for photosynthesis but shielded at the same time against lethal ultraviolet. It has been calculated that the green cells must therefore have been about thirty feet

below the surface of water, probably in pools and ponds shallow enough to lack strong convection currents (the ocean could not have been the starting place).

You could say that the breathing of oxygen into the atmosphere was the result of evolution or you could turn it around and say that evolution was the result of oxygen. You can have it either way. Once the photosynthetic cells had appeared, very probably counterparts of today's blue-green algae, the future respiratory mechanism of the earth was set in place. Early on, when the level of oxygen had built up to about l percent of today's atmospheric concentration, the anaerobic life of the earth was placed in jeopardy, and the inevitable next stage was the emergence of mutants with oxidative systems and ATP (adenosine triphosphate, a molecule that serves as a carrier of energy within living cells). With this, we were off to an explosive developmental stage in which great varieties of respiring life, including the multicellular forms, became feasible.

Some scientists have suggested



that there were two such explosions of new life, like vast embryological transformations, both dependent on threshold levels of oxygen. The first, at 1 percent of the present level, shielded out enough ultraviolet radiation to permit cells to move into the surface layers of lakes, rivers, and oceans. This happened about 600 million years ago, at the beginning of the Paleozoic era, and accounts for the sudden abundance of marine fossils of all kinds in the record of this period. The second burst occurred when oxygen rose to 10 percent of the present level. At this time, about 400 million years ago, there was a sufficient canopy to allow life to move out of the water and onto the land. From here on it was clear going, with nothing to restrain the variety of life except the limits of biologic inventiveness.

As another illustration of our fantastic luck, oxygen filters out the very bands of ultraviolet light that are most devastating for nucleic acids and proteins, while allowing full penetration of the visible light needed for photosyn-

thesis. If it had not been for this semipermeability, we could never have come along.

The earth breathes, in a certain sense. There may have been cycles of oxygen production and carbon dioxide consumption, depending on relative abundances of plant and animal life, with the ice ages representing periods of apnea, or cessation of respiration. An overwhelming richness of vegetation may have caused the level of oxygen to rise above today's concentration, with a corresponding depletion of carbon dioxide. Such a drop in carbon dioxide may have impaired the "greenhouse" property of the atmosphere, which holds in the solar heat otherwise lost by radiation from the earth's surface. The fall in temperature would, in turn, have shut off much of living, and in a long sigh, the level of oxygen may have dropped by 90 percent. This may account for what happened to the great reptiles; their size may have been all right for a richly oxygenated atmosphere, but they had the bad luck to run out of air.

Now we are protected against lethal ultraviolet rays by a narrow rim of ozone, thirty miles out. We are safe, well ventilated and incubated, provided we can avoid technologies that might fiddle with that ozone or shift the levels of carbon dioxide. Oxygen is not a major worry for us, unless we let fly with enough nuclear explosives to kill off the green cells in the sea; if we do that, of course, we are in for strangulation.

It is hard to feel affection for something as totally impersonal as the atmosphere, and yet there it is, as much a part and product of life as wine or bread. Taken all in all, the sky is a miraculous achievement. It works, and for what it is designed to accomplish,

it is as infallible as anything in nature. I doubt whether any of us could think of a way to improve on it, beyond maybe shifting a local cloud from here to there on occasion. The word chance does not serve to account well for structures of such magnificence. There may have been elements of luck in the emergence of chloroplasts, but once these things were on the scene, the evolution of the sky was absolutely ordained. Chance suggests alternatives, other possibilities, different solutions. This may be true for gills and swim bladders and forebrains, matters of detail, but not for the sky. There was simply no other way

We should credit it for what it is: for sheer size and perfection of function, it is far and away the grandest product of collaboration in all of nature.

It breathes for us, and it does another thing for our pleasure. Each day, millions of meteorites fall against the outer limits of the membrane and are burned to nothing by the friction. Without this shelter, our surface would long since have become the pounded powder of the moon. Even though our receptors are not sensitive enough to hear it, there is comfort in knowing that the sound is there overhead, like the random noise of rain on the roof at night.

This article is reprinted with permission from the New England Journal of Medicine, vol. 289, page 576, September 13, 1974.

Lewis Thomas is president of the Memorial Sloan-Kettering Cancer Center in New York. A physician, he served as dean at the New York University—Bellevue Medical Center and at Yale University Medical School.

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Catastrophes and Steady State Earth

Geologists have yet to bring together two fundamental views of life and the history of our planet

The Gideon Society-those purveyors of spiritual comfort to a mobile nation-persist in recording the date of creation as 4,004 B.C. in their marginal annotation to Genesis 1. Geologists believe that our planet is at least a million times more ancient-some 4½ billion years old.

Each of the major sciences has contributed essential ingredients to our long retreat from an initial belief in our own cosmic importance. Astronomy defined our home as a small planet tucked away in one corner of an average galaxy among millions; biology took away our status as paragons created in the image of God; and geology taught us how short a time our own species has' been present in the history of the earth.

This month we celebrate the centenary of the death of Charles Lyell, conventional hero of the geologic revolution-"the mirror of all that really mattered in geologic thought," according to one recent biographer. The standard account of Lyell's accomplishment runs in the following way: In the early nineteenth century, geology was dominated by the catastrophists—theological apologists who sought to compress the geologic record into the strictures of biblical chronology. To do this, they imagined a profound discordance between past and present modes of change. The present may run slowly and gradually as waves and rivers do their work; the events of the past were abrupt and cataclysmic-for how else could they fit into a few thousand years? Mountains were raised in a day, and canyons opened at once. Thus, the Lord interposed his will to break the rule of natural law and place the past outside the sphere of scientific explanation.

Loren Eiseley writes: "[Lyell] entered the geological domain when it was a weird, half-lit landscape of gigantic convulsions, floods and supernatural creations and extinctions of life. Distinguished men had lent the power of their names to these theo-

logical fantasies."

In 1830, Lyell published the first volume of his revolutionary Principles of Geology. He, so the standard account goes, boldly proclaimed that time had no limit. Having removed this fundamental constraint, he advocated a philosophy of "uniformitarianism"-the doctrine that made geology a science. Natural law is invariant. With so much time, we need invoke no more than the slow and steady operation of present causes to produce the entire panorama of past events. The present is the key to the past.

This tale of Lyell's position is no different from most standard accounts in the history of science: it is long on inspiration and rather short on accuracy.

A few months ago, while browsing through the stacks of Harvard's ancient library, I discovered Louis Agassiz's annotated copy of Lyell's Principles of Geology (more things are buried in libraries than this world dreams of). Agassiz was America's leading biologist and also her staunchest catastrophist. And yet his marginalia include an impossible contradiction if we accept the standard account of Lyell's achievement. Agassiz's penciled annotations include all the standard critiques of the catastrophist school. They record, in particular, Agassiz's conviction that the summation of present causes over geologic time cannot account for the magnitude of some past events; a notion of cataclysm, he believes, is still required. Nonetheless, he writes as his final assessment: "Mr. Lyell's Principles of Geology is certainly the most important work that has appeared on the whole of this science since it has merited its name." (It becurred to me that Agassiz might have been citing someone else's assessment from a published review; but I have consulted with several historians and we have concluded that his annotation reflects his own opinion.)

If catastrophists wore the black moustaches, if uniformitarians sported silver stars and white hats, and if Lyell was the sharp-shooting sheriff who kicked all the baddies out of town—the Manichaean or western-movie version of the history of science—then Agassiz's statements are absurd, for how could a wrongdoer at liberty praise the sheriff so obsequiously? Either the western script is wrong or Agassiz was crazy.

Why, then, did Agassiz praise Lyell? To answer that question, I must analyze Lyell's so-called uniformitarianism, in order to argue that modern geology is really a blend of concepts from both Lyell and the catastrophists.

Charles Lyell was a lawyer by



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profession, and his book is one of the most brilliant briefs ever published by an advocate. It is a mélange of precise documentation, incisive argument, and a few of the "quiddities, quillets [quibbles] . . . and tricks" that Hamlet ascribed to the profession when he exhumed a lawyer's skull from the graveyard. Lyell relied upon two bits of cunning to establish his uniformitarian view as the only true geology.

First, he set up a straw man to demolish. By 1830, no serious scientific catastrophist believed that cataclysms had a supernatural cause or that the earth was 6,000 years old. Yet, these notions were held by many laymen, and they were advocated by some quasiscientific theologians. A scientific geology required their defeat, but they had long before been routed within the profession by both catastrophists and uniformitarians. Agassiz praised Lyell because he brought a geologic consensus so forcefully to the public.

It is not Lyell's fault that later generations accepted his straw man as an accurate representation of the scientific opposition to uniformitarianism. Yet all of the great nineteenth-century catastrophists-Cuvier, Agassiz, Sedgwick, and Murchison in particular-accepted an earth of great antiquity, and they all sought a natural basis for the cataclysmic changes that occurred in the past. A 6,000-year-old earth does require a belief in catastrophes to compress the geologic record into so short a time. But the converse is decidedly not true: a belief in catastrophes does not dictate a 6,000-year-old earth. The earth might be 4.5 or, for that matter, 100 billion years old and still build its mountains with great rapidity.

In fact, the catastrophists were much more empirically minded than Lyell. The geologic record does seem to record catastrophes: rocks are fractured and contorted; whole faunas are wiped out (see my column of October, 1974). To circumvent this literal appearance, Lyell imposed his imagination upon the evidence. The geologic record, he argued, is extremely imperfect and we must interpolate into it what we can reasonably infer but cannot see.

The catastrophists were the hardnosed empiricists of their day, not the blinded theological apolo-

Secondly, Lyell's "uniformity" is a hodgepodge of claims. One is a methodological statement that must be accepted by any scientist, catastrophist and uniformitarian alike. Other claims are substantive notions that have since been tested and abandoned. Lyell gave them a common name and pulled a consummate fast one: he tried to slip the substantive claim by with an argument that the methodological proposition had to be accepted, lest "we see the ancient spirit of speculation revived, and a desire manifested to cut, rather than patiently to untie, the Gordian knot."

Lyell's concept of uniformity has four major, and very differ-

ent, components:

 Natural laws are constant (uniform) in space and time. As John Stuart Mill showed, this is not a statement about the world; it is an a priori claim of method that scientists must make in order to proceed with any analysis of the past. If the past is capricious, if God violates natural law at will, then science cannot unravel history. Agassiz and the catastrophists agreed; they, too, sought a natural cause for cataclysms and praised Lyell's basic defense of science against theology.

2. Processes now operating to mold the earth's surface should be invoked to explain the events of the past (uniformity of process through time). Only present processes can be directly observed. Therefore, we are better off if we can explain past events as a result of processes still acting. This again is not an argument about the world; it is a statement about scientific procedure. And again, no scientist disagreed. Agassiz and the catastrophists also preferred present processes, and they applauded Lyell's exquisite documentation of how much these processes can accomplish. Their disagreement concerned another issue. Lyell believed that present processes were sufficient to explain the past; catastrophists held that present processes should always be preferred, but that some past events required the inference

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of causes no longer acting or acting now at markedly slower rates.

3. Geologic change is slow, gradual, and steady, not cataclysmic or paroxysmal (uniformity of rate). Here we finally encounter a substantive claim that can be tested-and a point of real difference between Agassiz and Lyell. Modern geologists would argue that Lyell's view has largely prevailed, although they would also point out that his original insistence on a near uniformity of rate was stifling to the imagination. (Lyell, for example, never accepted the now-verified glacial theory that Agassiz developed; he would not concede that amounts of ice and rates of flow had been so different in the past.) Walter Sullivan argues persuasively in his most recent book that plate tectonics is the greatest triumph Lyell's uniformity, for so many apparently "cataclysmic" events-the giant rift that circles the earth and such high mountains as the Himalayas, for example-have been explained as results of the slow and steady operation of sea-floor spreading that continues today.

4. The earth has been fundamentally the same since its formation (uniformity of material conditions). This last major component of Lyell's uniformity is rarely discussed. After all, it is an empirical claim, and largely an incorrect one at that-and who wants to expose the false steps of a hero? Yet I believe that this uniformity was closest to Lyell's heart and most central to his concept of the earth. Newton's earth revolves endlessly about its star with no direction to its history. One moment is like all moments. Land and sea might change their positions, but land and sea exist through time in roughly the same proportion; species come and go, but the mean complexity of life remains forever constant. Endless change in detail, ceaseless constancy in aspect-a dynamic steady state, to use today's jargon of information theory.

Lyell's vision led him to propose, contrary to all evidence, that mammals would be found in the earliest fossiliferous beds. To reconcile the appearance of direction with dynamic constancy in

the history of life, he supposed that the entire fossil record represents but one part of a "great year"—a grand cycle that will occur again when "the huge iguanodon might reappear in the woods, and the ichthyosaur in the sea, while the pterodactyle might flit again through umbrageous groves of tree ferns."

The catastrophists took the literal view. They saw direction in the history of life, and they believed it. In restropect, they were

right.

Most geologists would tell you that their science represents the total triumph of Lyell's uniformity over unscientific catastrophism. Lyell's brief won the victory for his name, but modern geology is really an even mixture of two scientific schools-Lyell's original, rigid uniformitarianism and the scientific catastrophism of Cuvier and Agassiz. We accept Lyell's first two uniformities, but so did the catastrophists. Lyell's third uniformity, appropriately derigidified, is his great substantive contribution; his fourth (and most important) uniformity has been graciously forgotten.

Yet there is much to be said for Lyell's vision of steady state. A dynamic constancy may seem fundamentally at odds with clearly directional aspects of the history of life and the earth. Medieval Christianity encompassed both views. In the stained glass of Chartres, human history is displayed as a linear sequence beginning in the north transept and running around the nave to the south transept-a directional process: one creation, one coming of Christ, one resurrection of the dead. But correspondence also pervades the system, giving a timelessness to apparent direction. The New Testament is a replay of the Old. Mary is like the burning bush because both held within themselves the fire of God, yet were not consumed. Christ is like Jonah because both arose again after three days in extremis. The two visions-directionalism and dynamic constancy-are not irreconcilable. Geology, too, might seek their creative synthesis.

Stephen Jay Gould teaches geology at Harvard University.



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The Geologist as Private Eye

by Raymond C. Murray

Earth scientists have joined forces with other specialists to apply their expertise in criminal investigations

All geologists are detectives. Most use their knowledge about the earth to trace the movement of global plates, uncover the origin of ancient rocks, or locate hidden deposits of metals and fossil fuels. The microscopic clues present in fossil debris provide the material for determining the path of evolution. The evidence for the history of the moon has come from the study of rocks brought back by the astronauts. A small but increasing number of earth scientists, however, are applying their talents and tools not only to science and technology but also to one of the most important societal goals-justice. Forensic geology is the name given to that branch of the earth sciences that uses rocks, minerals, fossils, soils, and related materials and ideas to provide evidence in criminal investigations and trials.

The modern criminologist employs fingerprints, tool marks, paint, glass, hair and fibers, firearms identification, and other physical evidence. In general this type of evidence assists an investigation either by providing clues that lead to a suspect or by subsequently assisting in convicting the guilty or exonerating the innocent.

The use of geology in crime detection began, as did many of the other kinds of physical evidence, with Sherlock Holmes. Sir Arthur Conan Doyle, who wrote the Holmes series between 1887 and 1893, had his fictional detective suggest many of the methods that were later developed and applied by professional scientists in real cases. Dr. Watson, like all the latter-day Holmes fans, knew that the

great detective could "tell at a glance from which part of London the various splashes of soil on his trousers had been picked up." In 1893 Hans Gross, an Austrian professor of criminology, published the Handbook for Examining Magistrates. This volume was to have a profound effect on the development and use of science in criminal investigation. Although no actual cases involving forensic geology had appeared at the time of publication, Gross made the prophetic statement, "Dirt on shoes can often tell us more about where the wearer of those shoes had last been than toilsome inquiries." With the idea appearing in print, in both fiction and the professor's Handbook, it was not long before minerals, rocks, and fossils in the hands of a geologist would become clues and evidence in an actual criminal case.

In October, 1904, Georg Popp, a chemist, miscroscopist, and earth scientist in Frankfurt, Germany, was asked to examine the evidence in a murder case in which a seamstress named Eva Disch had been strangled in a bean field with her own scarf. A filthy handkerchief had been left at the scene of the crime and the nasal mucus on the handkerchief contained bits of coal, particles of snuff, and most interesting of all, grains of minerals, particularly hornblende. A prime suspect was known to work both in a coal-burning gasworks and at a local gravel pit. Popp found coal and mineral grains, including hornblende, under the suspect's fingernails. It was also determined that the suspect used snuff. Examination of soil removed from the suspect's trousers revealed that minerals in a lower layer in contact with the cloth matched those of a soil sample taken from the place where the victim's body had been found. Encrusted on this lower layer, a second soil type was found. Examination of the minerals in the upper layer revealed a mineralogy and size of particle, particularly crushed mica grains, that Popp determined were comparable with soil samples collected along the path that led from the murder scene to the suspect's home. From these data it was concluded that the suspect picked up the lower soil layer at the scene of the crime and that this lower and thus earlier material was covered by splashes of mica-rich mud from the path on his return home. When confronted with the soil evidence the suspect admitted the crime, and the Frankfurt newspapers of the day carried such headlines as, "The Microscope as Detective."

It is impossible to determine from the distance of three-quarters of a century how a contemporary forensic geologist or a jury would evaluate the geologic evidence amassed by Popp. Nevertheless, one fact is evident. Minerals had been used in an actual case, fulfilling Gross's prophecy and providing a real-life example worthy of Holmes. Popp worked on many other criminal cases and made substantial contributions to forensic science. He probably should be considered the founder of forensic geology.

In 1906 Conan Doyle became involved in an actual criminal case during which he applied some of the methods of his fictional creation Holmes. An English solicitor was accused and convicted of killing and mutilating horses and cows. After serving three years in prison he was released but not given a pardon despite some evidence that he was actually innocent of the crimes. Doyle observed that the soil on the shoes worn by the convicted man on the day of the crime was black mud and not the yellow, sandy clay found in the field where the animals had been killed. This observation, combined with other evidence, ultimately led to a full pardon and contributed to the

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England.

Today, rocks, minerals, fossils, and other natural and synthetic materials are studied in connection with the thousands of criminal cases tried each year. The Federal Bureau of Investigation laboratory in Washington, D.C., one of the first forensic laboratories in the United States to have geologists study soils and related material as physical evidence, is a worldwide leader in forensic geology. Several other major laboratories, such as that of the New Jersey State Police; the Virginia Bureau of Forensic Sciences: the famous Centre for Forensic Sciences in Toronto, Canada; and the Home Office, Central Research Establishment, at Aldermaston, England, employ geologists. They have made many contributions to the science of forensic geology and thus to justice. Regretfully, there are also many public and private laboratories where lack of trained scientists and equipment or simply the investigators' ignorance of the value of earth materials as evidence has led to the overlooking or misuse of important geologic clues.

Physical evidence, unlike human evidence, cannot subvert the criminal justice system through a combination of memory, emotion, or outright lying. But the integrity and competence of the scientific expert in a criminal case must be equal to the challenge. Physical evidence is divided into two general types, individual items and class items. Fingerprints, some tool marks, and spent ammunition are said to be individual items, meaning they have only one possible source. But most physical evidence-for example, blood, paint, glass, and hair-is grouped under the heading of class items and could come from a variety of sources. The value of a class item in general depends on how common that item is. Forty-three percent of the population has type O blood, whereas only 3 percent of the population has type AB. Type AB blood would thus be a more valuable bit of evidence than type O. Similarly, the paint from a 1932 Rolls Royce would be more valuable as evidence than that from a

Although geologic materials can seldom be considered as truly indi-

1970 Ford.

vidual items, there are exceptions. One such was a vandalism case in which a concrete block was broken into fragments that were thrown through a number of store windows from a moving car. In that instance it was possible to piece together the fragments found in the stores and those remaining in the car to reconstruct the original block. Not only did the pieces fit together but individual mineral grains lined up across the pieces and all the fragments were shown to be of the same kind of concrete.

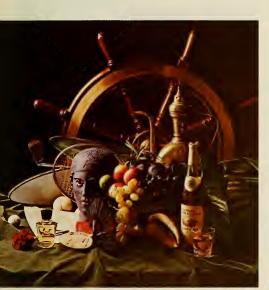
In most examples, geologic material is class evidence, but its value lies in the fact that the different kinds and combinations of rocks, minerals, fossils, and related materials are almost limitless. The evidential potential of geologic materials is therefore greater than that of almost all the other kinds of physical evidence of the class type.

There are more than 2,200 different minerals, many of which are not common. Almost all of these minerals exist in a wide range of compositions, with the result that there is an almost unlimited number of recognizable kinds of minerals. More than a million different kinds of fossils have been identified. Most fossiliferous rocks have populations of fossils that commonly reflect the environment or deposition in which the rock was formed. These groups of fossils provide a very large number of possible combinations.

Almost all rocks-igneous, sedimentary, and metamorphic-are composed of minerals. In any given igneous or metamorphic rock, the kinds and amounts of minerals, their size and texture. represent a wide range of variations. The possible combinations of minerals, the sizes and shapes of minerals, and the kinds and amounts of cement between the grains in sedimentary rocks offer an almost unending diversity. The weathering processes that break up rocks and produce soil add new dimensions to the possible variations. Also, in most urban areas the soils contain particles contributed by man, which further increase the complexity and diversity.

Anyone who has seen the Grand Canyon, noticed the variety of pebbles in a stream bed, or simply observed the color differences in the soils of his own backyard can

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appreciate the variety and rapid changes that exist in natural earth materials.

In a case of rape in an eastern United States city, the victim reported that the crime took place in a vacant lot, which was underlain by the beach sands of an ancient glacial lake. The suspect had sand in the cuffs of his trousers. Study of the sand from the cuffs and samples collected at the crime scene showed that the two sands were comparable. Both contained the same minerals and rock grains in the same amounts. Thus it was established with a high degree of probability that the two samples could have come from a common source. One of the rock types was fragments of anthracite coal. These fragments were very common but were not natural to the area. Coal fragments are widely found in the soils of most of our older cities. In this case, however, there was too much coal in the sand. Further investigation revealed that sixty years before the crime the site had been the location of a coal pile for a laundry. Although the minerals involved in this case might have been duplicated in other places, the presence of the coal became a crucial factor in greatly increasing the probability of a single common source. This geologic evidence, when combined with other evidence and testimony by the victim, led to the conviction of the suspect.

Many man-made and commercially manufactured mineral products such as face powder, cleaning powder, abrasives, masonry, and wallboard become the study material for the forensic geologist. Hundreds of criminals have been brought to justice because of the minerals found on their burglary tools or clothing.

Most interesting is the insulation material used in safes and strong boxes. When fire-resistant safes are broken into by drilling, blowing, cutting, or prying, the fire insulating material that fills the space between the outer and inner metal walls is disrupted. It commonly clings to the tools and clothing of the safe breaker. There is a classic case in which a man was arrested and brought to the police station on a routine minor charge. An observant detective, noticing that the suspect appeared to have a severe case of dandruff, examined his hair. The substance found was, not dandruff, but diatoms, the microscopic fossils that make up the diatomaceous earth used to insulate some safes. On further examination it was learned that the diatoms in the suspect's hair were of the same species as those present in the insulation of a safe that had been blown the previous day. The suspect was accordingly charged with the burglary.

Geologic maps can often be used in crime investigation to outline the areas where rocks and minerals associated with crimes or suspects could have originated. The owner of some valuable gems found chips of common rock instead of precious stones when she opened the cargo box that had been sent by air. Study of the chips indicated that they came from a foreign country that was a stopover point on the air route. Examination of the geologic map for that area indicated the probable source of the rock chips. This evidence cleared the air-freight handlers at the final destination and led to the apprehension of those responsible for the substitution.

Even topographic maps, which record contour lines and indicate the elevation of land, have made their contribution. An informer reported that an illegal still was located somewhere between two towns in southern New Jersey in an area of swamps and higher gravel ridges and that the water well at the site of the still reputedly had a water level twenty feet below the ground. Since the groundwater table and the swamps were on approximately the same level, to find the still it was necessary to find a place on a ridge twenty feet above the local swamp level. A study of the topographic maps of the area showed there was only one place on one ridge where the elevation met that requirement. A church occupied that location. A warrant was obtained and the still was found in the church cellar.

Geology can thus be seen to have made many contributions to crime detection and justice. These contributions will undoubtedly increase and become even more significant as imaginative criminal investigators realize the value of geologic material as evidence and make use of competent forensic geologists.





A Tale of Two Butterflies

by John R. G. Turner

Colorful group advertising is an effective way to ward off predatory birds

The tropical rain forests of the world are at a critical stage. Facing almost total destruction from economic and population growth in the next twenty years, for a brief period they will be both relatively unspoiled and readily accessible to biologists by air and road. As O.W. Richards, an authority on rain forest ecology has pointed out, the tropics have been a particularly fruitful source for original ideas in biology (both Darwin and Wallace did their major work there), and we now have our last chance to find out more before the ecosystems are gone forever.

Of the enormous number of tropical organisms available, some of us have chosen to study Heliconius, a group of butterflies with curiously elongated wings and brilliant color patterns of black, red, yellow, white, and iridescent blue. These butterflies have a distribution that encompasses all of the damper parts of the American tropics. Adding to their biological interest, the habits and characteristics that have evolved within this family come as a great surprise to anyone acquainted with the life histories of butterflies in the North Temperate Zone.

The current research interest in

Heliconius started one day in the early 1950s when that grand old naturalist William Beebe found a Heliconius caterpillar on a passionflower vine that decorated his desk in Trinidad. His find led him to initiate a program of scientific investigation that is still going full strength in North, Central, and South America.

These butterflies, at once a collector's delight and a classifier's nightmare, had been famous—or notorious—with lepidopterists for years. Although there are only 40 or 50 species (Keith Brown of São Paulo, Brazil, the authority on their classification, has yet to determine exactly how many there are), some 750 Latin names have been given to what people regarded as species and races of Heliconius, a result of the almost unbelievable variability of some of these butterflies.

In parts of their range, certain species of Heliconius go off the deep end and produce about 50 recognizably distinct varieties-a number of which were once thought to be separate speciesall flying together in the same area. In one part of French Guiana, ex-convicts from the penal colony on Devils Island used to be commissioned to net these in great numbers, and judging from the collections of the world's museums, butterfly dealers must have handled them by the crate.

With this variability. Heliconius

A hybrid Heliconius melpomene perches on a leaf in a laboratory at the University of York. The offspring of a butterfly native to the Amazon River and one from Trinidad, its intermediate combination of colors has helped researchers unravel the genetic pathways of the myriad mimetic patterns that have evolved in this species.

presents a paradoxical uniformity. In Trinidad there is a Heliconius butterfly that is plain black with a single, brilliant red splotch on its front wing; the local children call it the postman (after the British uniform for that profession). It is actually not one species but two, Heliconius melpomene and H. erato. Although the adults look virtually identical, we know that these are different butterflies because they have difdifferent caterpillars, pupae, and different food plants. What is more, if you handle these butterflies roughly, so that they become upset, the two species have different smells-erato smelling of witch hazel and melpomene of fried rice.

Pairs of identical-appearing species are something of a habit with Heliconius: in southern Brazil there is a pair with red splotches and yellow lines on both wings; in the Amazon Basin we find a pair with yellow splotches and a pattern of orange rays, although here one can tell them apart because the rays are slightly different; and in Panama there is a pair like the ones in southern Brazil, except that the yellow bars are only on the rear wings (one can tell these apart with field glasses, because in one species the yellow bar turns forward on the underside of the wing, and in the other it turns back). The surprising thing about these pairs of species is that they are just H. melpomene and H. erato all over again. Over most of tropical America they are found together, changing now to this pattern, now to that, but always in strict parallel with each other (except in the western rift valley of Colombia).

How do we know that these are the same species? For one thing, we have never had any trouble crossing a melpomene from one part of tropical America with a melpomene from another, and the same goes for erato. More cogently, where the ranges of the different patterns meet, the crossing occurs naturally; this is what produces the huge bursts of variation that

have delighted the eyes of collectors and swelled the bank balances of dealers.

Such a phenomenon looks at first sight like a good reason for believing in special creation, and special creation by a philatelist at that. Why, and how, did such a pattern of variation evolve? Two completely different-looking butterflies may belong to the same species, while two butterflies so similar in appearance that you have to sniff them to tell the difference, may be specifically distinct. The close similarity between melpomene and erato is an example of what is called Müllerian mimicry-after the German biologist who first explained it.

The butterflies do not have a pleasant taste to birds; in laboratory experiments, birds quickly learn not to eat them. On rare occasions, a wild bird has been seen to "forget" and snap one up, only to eject the prey with a violent shaking of the head and other signs of agitation. Birds thus learn to recognize and avoid the colors and patterns of unpleasant species; they can probably also learn this indirectly simply by seeing another bird having an unpleasant time with a butterfly.

The bright colors of Heliconius are thus a form of advertising in a world that is full of palatable insects with a high degree of camouflage. If an insect's camouflage is penetrated by a predator, it will be eaten. The conspicuous Heliconius butterflies take no chance of being mistaken for one of these green, brown, or gray creatures, with their imitations of leaves, bark, and mottled sunlight; Heliconius have their brand image, and it is unambiguous. Generations of selection by predators have made their color patterns distinct, beyond all possibility of confusion, from the russet orange of the checkerspot butterflies that were probably their ancestors. It has often been said that bright, simple patterns are "memorable," that predators learn them easily in the way that we may readily learn to recognize a bold, simple trademark; but I believe that at least equally important has been selection in favor of looking as different as possible from those camouflaged forms for which predators are constantly hunting.

While it does not pay them to look like camouflaged leaf insects, it is advantageous for the various species of Heliconius to look like one another if they occupy the same area because there are benefits in syndicated advertising. When two Heliconius species look alike, the cost of the advertisment-the number of butterflies that would have to be tasted and maimed or killed in every generation to educate and reeducate their predators-is distributed between the two species and both benefit.

So far, we can explain the resemblance of melpomene and erato to each other, but we are then faced with explaining why they have such different patterns in the different geographic areas of their distribution. After all, once you have a good (or in this case, bad) brand image, it pays to keep it. A mutant Heliconius, which has, say, lost its red marks, is likely to be sampled by a hungry and curious bird on the offchance that it is nice to eat. Therefore evolution away from an established and successful warning pattern should be difficult. Yet this must have happened repeatedly to produce the numerous geographic races of these butterflies.

To sort out this paradox, we have to reconstruct the vegetational history of South America. Today Heliconius butterflies inhabit the great Amazonian rain forests and other areas of dense vegetation, which cover most of the continent except for the high mountain ranges and areas of low rainfall. For some years I have been convinced, although the view was not popular, that during the last Ice Age there must have been dry periods that reduced the extent of the rain forests to comparatively small "islands" surrounded by savannas. A few years ago, geologist-ornithologist Jurgen Haffer came to the same conclusion from studying the distribution of Amazonian birds, and he managed to work out where the patches of restricted rain forest probably were. Haffer's map of these hypothetical Ice Age forest refuges showed that they coincide with the centers of distribution of the races of Heliconius butterflies. The different races with their dissimilar color patterns must have evolved in these forest islands, and then, as the climate of South America became wetter again 8,000 years ago, they spread out with the readvancing forest until adjoining races met at the edges of their respective distributions.

A confirmation of this idea comes from the present-day position of the range borders of the races of Heliconius: they occur in places where the advancing butterflies have been halted by natural barriers, such as the wide rivers of the Amazon Basin, strips of grassland along the crest of a range of hills, and in the Guianas, by the curious "white sand forest," which contains very few passionflower vines, the larval food plant a Heliconius population must have to establish itself. This is exactly the situation we should expect if the races of butterflies formerly had much more confined distributions than

they do now. But what is it about being cut off in a forest island that makes a butterfly abandon an already successful warning pattern and produce another one? The British geneticist Philip Sheppard has come up with an answer to that question. A species will keep its own warning pattern unless it finds itself in the same area with a more abundant and also unpleasant-tasting species whose color pattern is not too different from its own. Most birds will be "turned off" by the more plentiful pattern; any mutant member of the rarer species that looks like the common one will be strongly favored by natural selection and the two patterns will converge. This will of course only happen if the patterns are al-ready similar; if they are too different, there will be no means by which they can evolve to be like each other, for there is no way of radically changing a pattern at a single step.

What must have happened in the forest refuges is what we know happens on oceanic islands. Species become extinct at intervals and tend not to be replaced. Colonists accidentally transported from other islands or the mainland are likely to be of some other species. Gradually, therefore, islands develop differing faunas. The Heliconius butterflies were probably flying with rather different butterflies in each forest island, and when they cohabited an area with a more abundant species that had a pattern not too different from their own, they evolved an altered pattern to match that of their coinhabitant. As they were confined in the forest refuges for between 1,500 and 7,000 years during the last big glaciation, and as they can go through a generation in as little as three weeks, there was plenty of time for this to happen.

If these ideas are correct, then we should be able to find evidence of Heliconius species altering their pattern in response to local changes in the fauna today-and we can. H. erato, for example, exists without H. melpomene in three parts of its range: Mexico and the northern parts of Central America; Argentina and Uruguay; and the western rift valley of Colombia. In the northern and southern areas, the absence of melpomene does not affect the coloration of erato. Clearly the warning pattern works very well in its own right, and even though melpomene probably tastes worse than erato, the latter is perfectly able to go it alone in educating its would-be predators. Further, in these areas there are very few other Heliconius species, and none of them looks anything like erato, which consequently cannot evolve a new mimetic pattern.

In the western rift valley of Colombia, however, there are many other species of *Heliconius*; one is *H. cydno*, a relative of

melpomene, which has blue, white, and yellow patterns instead of the usual red, orange, and yellow of melpomene. In this one place, erato has evolved away from its normal red coloring and mimics the local blue and yellow eydno.

The zebra butterfly (H. charitonius) occurs through most of its range in the southern United States, Central America, and the Antilles, with either no other Heliconius or with other species that are so completely different that it cannot mimic them. In Ecuador, however, and in a littleknown part of northwestern Peru, it coincides with a local species, H. atthis, which has a similar but different pattern of yellow bars. Here the zebra becomes a mimic of the local species, even to the extent of having wings that are less elongated than usual to match those of *H. atthis*.

What makes all this more interesting than simply the story of two extraordinary butterflies is that when such organisms change their color patterns, they are adapting their outward forms to changing ecological circumstances (in this case the altered composition of the fauna with which they live). And this change of form to meet altered ecological circumstances, known as adaptive radiation, is one of the major processes of evolution.

Consider today's most successful vertebrates, the mammals, which have diversified into all manner of methods of locomotion-walking, running, flying, burrowing, swimming, and gliding-and to all kinds of food and habitat. The alterations in the color patterns of Heliconius are analogous to the beginnings of this process. By analyzing the evolutionary history of these butterflies we can come to understand more about the various ways in which adaptive radiation can work.

First, the process can apparently begin with the different adaptations of races to local ecological circumstances, which then can eventually lead to the evolution of distinct species. We be-

lieve that H. melpomene and H. erato have been mutual comimics for a considerable time. Before the last round of glaciation both probably had the pattern with the red splotch and the yellow bar, which gave rise to the other patterns in the Amazon Basin. This explains why the red splotch is now found with a wide, but disjunct, distribution in both species. (If they had started off with the Amazon Basin pattern, we would have to assume that the red splotch arose independently several times, which is unlikely.) Before that time, they were probably still mimics, and our best guess at what they looked like is provided by some of their relatives such as the zebra butterfly (which is nonmimetic and consequently has probably altered little from the ancestral pattern). In the remote past, both melpomene and erato probably had a zebra pattern of yellow bars.

But there were several glaciations in the Pleistocene, all of which must have split the forest up into island refuges. Suppose that melpomene and erato were confined in these earlier refuges and formed parallel races in them analogous to the present ones. Suppose that these races eventually became full species, unable to cross with the ancestors from which they evolved. In that case, as the mutual mimicry would have been retained throughout the process, pairs of mimetic species would have evolved, one member of each pair related to melpomene and the other to erato (such relationships can be determined by similarities in anatomy, particularly of the pupae). This is exactly what we now find: H. melpomene has a relative, H. luciana, that has a black-and-white pattern. It is a beautiful mimic of H. antiochus, a relative of H. erato. There are several other such pairs; in each, one species is related to melpomene and the other to erato. Obviously the events that happened in the last glaciation must have occurred several times before. This last time they have only led to race formation; previously they led to full speciation.

Second, the process can result from the populations of a species responding to a change in their local ecological circumstances, rather than from their genetic isolation from each other. By convention, it was thought that only genetic isolation (absence of crossing with other populations) triggers adaptive radiation, and at first sight, that would seem to be what is operative here: evolution by isolation in refuges.

We know, however, that Heliconius butterflies are extremely sedentary. In one experiment individuals of H. erato were marked at two points thirty yards apart. Over a period of 74 days very few of the butterflies marked at one point turned up at the other; most remained at the original marking spots. In Trinidad, a most elegant study of H. ethilla by population ecologists Paul Ehrlich and Larry Gilbert showed how this restriction of movement results from individual butterflies learning a limited home range that they patrol day after day, visiting particular flowers at regular times. The upshot of all this is that, even today, while they are still widely distributed, there will be little cross mating between populations of Heliconius species although they may be separated by only a few hundred yards. Yet these populations do not evolve different color patterns. It is only when populations are subjected to a prolonged change in their local ecology that the evolution of a new pattern occurs.

Last, we can untangle the actual genetic changes that produce one color pattern from another at the beginning of the process. We do this simply by crossing different races and then working out how the patterns are inherited by performing further crosses according to regular Mendelian principles. The most extensive experiments have involved crossing races of *H. melpomene* from the Amazon Basin with the very different-looking races from Trinidad and southern Brazil. In the

first generation the result is a uniform brood of butterflies that look more like the Amazonian parent; but on crossing these among themselves, many other patterns are produced, including some that appear in neither parent (like a black forewing tip or a square yellow splotch). This burst of variation (which also occurs in the wild in those places where the races cross naturally) is the result of the Amazonian and extra-Amazonian butterflies differing by a half-dozen of the genes that affect color pattern. One gene, for example, adds orange rays; two or three acting in concert convert a red forewing patch to a pattern of yellow dots.

So when these color patterns evolve one from another, the end result is not accomplished in a single step, but through building up the new pattern piece by piece. This must surely be the primary method by which elaborate adaptations are produced in other animals during the course of evolution and is the reason that there are still a good many different warning patterns among the butterflies of South America, rather than just one over-all pattern for all the distasteful species: two very dissimilar Heliconius butterflies cannot become mimics of each other because it then requires too many mutations all at once to produce an acceptable mimic. One mutant at a time will not do the trick, and an illadapted intermediate stage, as Darwin pointed out, means no evolution.

That is not the end of the Heliconius story. For example, some fascinating things are being discovered about the ecology and behavior of these butterflies. Within the home range that a Heliconius patrols during the day there is usually a particular roosting place, most often on a bit of dried creeper vine, that night predators such as toads, tree frogs, or hunting spiders, cannot climb down. The roosts are communal, and the butterflies return faithfully every night. Sometimes these roosts are occupied by several species, making an impres-



JOHN R.G. TURNER



Munching on passionflower vines, caterpillars of the comimetic species H. melpomene (above) and H. erato (left) can be distinguished by their differently colored spots. As adults, however, they will be so nearly identical in appearance that lepidopterists find it difficult to distinguish them. Predatory birds have learned to avoid both species.





sive sight just before sundown as the butterflies hover around, jostling one another for a perch.

Staying in one place creates problems for the female butterflies: the Passiflora vines-the only plants Heliconius caterpillars eat-have evolved an elegant defense by having nectaries not just in the flowers but on the leaves and petioles as well. Ants love the sugar in the nectaries, so a Passiflora vine is usually heavily populated with feeding ants. Ants also love butterfly eggs and young caterpillars, and their predation on the latter insures that not too much of the vine is eaten. This presents Heliconius females with a problem that they can overcome only by laying their eggs on the outermost growing tips of the vines where, because the nectaries tend not to be fully developed in that area, ants seldom go. But young caterpillars chew away the support for other eggs and younger caterpillars, with the result that only a few eggs at a time can be laid on one tip. Therefore, unlike most temperate zone butterflies, which have an abundant variety of food plants in their habitat, lay all their eggs in a matter of days (in some cases traveling quite widely to do so), and then die within a week or so, a Heliconius remains in one restricted area, lays a few eggs per week as suitable vine tips can be found, and lives at least six months.

Butterflies are popularly supposed to imbibe only the nectar of flowers, but many of them have a taste for stale urine and the juices exuding from manure. Butterflies most likely need nitrogen compounds, which they can get from these sources. Larry Gilbert has discovered that Heliconius, alone among butterflies, eat pollen, which they digest externally by salivating on a cake of it that they carry for days on their coiled-up tongues; the yellow cake of pollen is one way of telling certain Heliconius species apart from their mimics in other families (mimicry between families is yet another story). Gilbert believes that the pollen is necessary for the continued health of these butterflies and particularly for the production of eggs over the whole of their long life-span.

Finding pollen, however, and for that matter nectar, in a tropical forest where few plants may be flowering at any one time is not easy; and this may be the reason that the butterflies have a learned home range, within which they know the location of their food flowers. Gilbert found that the accidental destruction of one of the pollen plants being visited by the population of H. ethilla he was studying caused the butterflies radically to alter their home ranges.

There is thus a whole constellation of adaptations—pollen feeding, restricted home range, communal roosting, and great longevity—all tied up with the problems of living in a tropical rain forest. Interpreting them is made harder by the absence of extensive work on the ecology of other tropical butterflies, so that we do not know how many are peculiar to Heliconius and how many are the norm in the tropics.

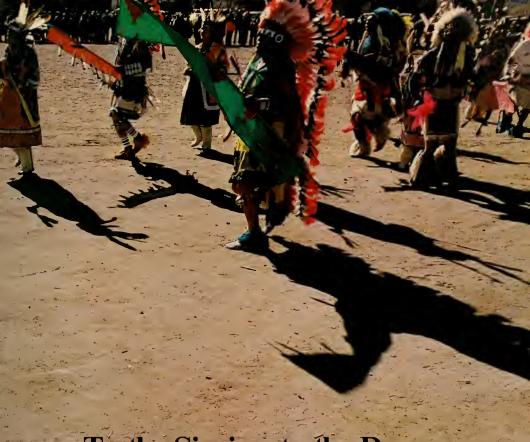
The bright warning patterns and the distastefulness of Heliconius are probably also part of the same interlocking set of adaptations. For one thing, not being eaten must increase longevity. For another, being distasteful is one of those characteristics that in general can be called "altruistic": as those that are eaten tend to leave fewer offspring, there would appear to be no way in which such altruistic characters as a bad taste and warning color could evolve under natural selection. It does the martyr that is tasted by a bird no good to have educated the predator if it is mangled in the process. There is one circumstance, however, in which altruism makes sense genetically, and it is familiar to most of us: it is beneficial to the survival of one's own line to be altruistic to one's own descendants, for they carry some of one's own genes. Protection of descendants is possible with the peculiar population structure of Heliconius: since the butterflies The bright colors of the zebra butterfly advertise its unpleasant taste to animals that might prey on it. Evolutionary geneticists believe that the ancestral pattern of present-day Heliconius butterflies was similiar to this one.

do not wander and since they live up to six months, with only three weeks lived as a caterpillar and a chrysalis, a *Heliconius* butterfly flies in the forest with its own children, grandchildren, and even further descendants. The beneficiaries of an altruistic act, such as educating a local bird, will be some of the immediate descendants of the martyr.

We do not know how many thousands of years have passed since a butterfly that was something like a checkerspot or fritillary began evolving into a highly forest-adapted Heliconius. It would be nice to see the complete sequence, but that of course is impossible. We can get some idea of what it was like though. Some of the close relatives of Heliconius in South America still live in comparatively open country and have characteristics intermediate between fritillaries and Heliconius. What is more, evolution has a habit of partly repeating itself. There is one North American checkerspot, the Baltimore butterfly (Euphydryas phaeton), with a color pattern rather like a Heliconius; in Canada it has expanded the black markings, which in most checkerspots are merely a lacework over the orange and yellow colors, leaving a striking pattern of black and yellow spots. This insect is possibly following part of the evolutionary path that was traced by the ancestral Heliconius. It would be an interesting butterfly to study.







To the Singing, to the Drums

by N. Scott Momaday

It is a recurrent pilgrimage, and it is made with propriety, a certain sense of formality. I understand a little more of it each time. I see a little more deeply into the meaning of formality, the formality of meaning. It is a religious experience by and large, natural and appropriate. It is an expression of the spirit.

The Taimpe is an old society in the Kiowa tribe, dating back to the time of the Sun Dance. Not much is known of its origin; there are various accounts. An old woman, Ko-sahn, who knew many

things and who is dead now, told me the following story:

"There was a young man who knew that he must go off by himself. It was necessary that he do this, for it was to be done for the people. He went out upon the prairie where it was very dangerous, for there were enemies all around. He came to a high place, a kind of little mountain, which was overgrown with sagebrush and mesquite and there was one treer The young man heard something, a work perhaps, but strange and froublesome, and he was afraid. He



climbed the tree and hid among the branches. From there in the tree he watched the approach of his enemy. The enemy was outfitted in the regalia of the wolf clan of his people. He wore the hide of a wolf, and he carried a bow and arrows. The wolflike man crept among the bushes, moving strangely, crouching and peering all around.

"By and by he came beneath the tree, and there he stood still. The young man in the tree dropped down upon his enemy and killed him. Then the young man took up the enemy's arrows in his right hand and held them high and shook them. They rattled loudly like dry leaves in a hard wind, and to this music the young man danced around his dead enemy. The people heard the music and came to see what was going on. They were very happy for the young man, and they praised him."

This, said Ko-sahn, is how the

Taimpe—the Gourd Dance—came to be, and she said it in the old, certain way, the way of the story-teller, nodding her head and speaking straightly, not to be in doubt or doubted.

Facets of the story flash upon me. I move toward the center with the others, dancing—yet not dancing, really—edging upon the music, that other, quicker element, fitting my motion to it slowly, waiting to enter wholly into it. The facets are



the leaves of the solitary tree, glittering in the sky. I imagine the young, legendary man there, coiled. But I do not see him apart from the tree. His limbs are the limbs of the tree, his hair the splinters of light that pierce the shadows. His enemy is vaguely there in the mottled foreground, waiting.

The celebration of the Gourd Dance is performed on the Fourth of July at Carnegie, Oklahoma.



INTERLUCE BEFORE CANCE AT SANTA CLARA PUEBLO, NEW MEXICO-JOHN RUNNING

From the window of the plane I can see to the horizon. Even at 25,000 feet there is a sense of vastness in the landscape of the Great Plains. I wonder that it always takes me by surprise. It is a mood in the earth, I think, suffered here only, a deep, aboriginal intelligence in the soil, deeper than the intricate geometry that I see below, as deep as ever ran the roots of that single tree or the blood of the buffalo.

I anticipate the air. It is warm and heavy in July; you seem to move against it, to spend yourself upon it; it confirms you. I watch the ground rise up to the window, feel for the touch of it. Space becomes lateral and infinite, faintly distorted—I think of seeing through a glass of water.

At the Will Rogers World Airport at Oklahoma City my father

and my three daughters are waiting for me; he spills the girls into my arms. Something now of the ritual proper has begun; generations have come together; the blood has begun to flow toward the center of time.

My children have an understanding of the occasion, rather a perception, not of what it is—that will likely come later in their lives—but that it is. It is a formality that gives shape to their lives.

From the time I was a small child I have heard stories from Kiowa tradition, and now so have my children, for I have seen to it. The stories are wonderful, engaging the imagination closely. They have a vitality that is peculiar to the spoken word; it does not exist in writing or it does not exist to the same degree. This vitality informs the Gourd Dance,





KIOWA CHILD BEING DRESSED FOR FANCY DANCE; CARNEGIE, OKLAHOMA-MARCIA KEEGAN

too; it is as if the dance is told in a story, imagined, realized in the force and nuance of an ancient language; there is that character to it, that quality of invention, of proportion, of delight.

The songs are torrential. They work a flood upon the afternoon. The sound is full of energy. Little by little I take it in, appropriate it to my mind and body. The sun beats down harder as the afternoon goes on. The dance ring is full of dazzling light. Banners move softly against the vague backdrop of the trees. Perspiration

runs in my hair; my skin and clothing are wet with it. It is as if I am suspended between the music and the heat. I feel good, strangely exhilarated and strong, as if I could dange on and on and on, so long as the songs are alive in the air.

We drive westward on the freeway. The little girls chatter in the back seat. My father's hands are dark, large-veined, laid lightly on the steering wheel of the rented car. I used to stand beside him when he painted, watching him touch the brush to the paper, wondering how he could make such fine lines of color, how it was that his hand was so sure, so true to him. It occurs to me now that his granddaughters, too, must wonder at the same thing in the same way. Cael, the oldest, has gone to school at his easel. Certainly, she sees that his hand is an instrument that realizes the image in his mind's eye upon the picture plane. She will be a writer and a painter, she tells me. She will illustrate her own books.

At Chickasha we are on the edge of the old world that I knew as a child. We leave the



GIRLS ON THEIR WAY TO FEAST DAY ANIMAL DANCE; SAN ILDEFONSO, NEW MEXICO-JOHN RUNNING

freeway and proceed on Oklahoma 9, a more familiar and congenial way. At Anadarko we stop at the Southern Plains Museum to look at the arts and crafts exhibit there. This, too, we do each year, and always at the same time of day. It is where I complain that we are late, that the dance has already begun.

"How much farther?" asks Brit, the baby, who is six, when we are on the road again. "Oh, a few miles, not far," answers Jill, whose tenth birthday it is. "Oh, well, then." Brit thinks it will be too hot at the dance. Nevertheless, she is looking forward to it; there will be children she sees just this one time each year; she will observe how they have grown; and perhaps there will be presents.

The earth is red along the way. There are escarpments like great, gaping flesh wounds in the earth. Erosion is an important principle of geography here, something deep in the character of the plains. Nowhere else on earth, I suppose, is the weather so close at hand as it is here.

My father begins to recognize the landmarks of his growing up,

and this excites the girls and me. "My dad and I used to come this way in a surrey," he says, pointing out a grove. "There we used to stop, every time, and eat. We ate watermelons. My dad loved watermelons." The girls look hard into the grove, trying to see the man and the boy who paused there in the other time.

Carnegie is a small, unremarkable town in the southern plains. It is like other towns thereabouts, essentially bland and tentative seeming against the huge, burning landscape. In July the wide, glass- and metal-bordered streets not only reflect the sun, they seem to intensify it. The light is flat and hard just now in the early afternoon; the day is at white heat. Later the light will soften and colors will emerge upon the scene; the town will melt into motion, but now it seems deserted. We drive through it.

The celebration is on the north side. We turn down into a dark depression, a large hollow among trees. It is full of camps and cars and people. At first there are children. According to some centrifugal social force, children function on the periphery. They run about, making festival noises. Firecrackers are snapping all around. We park and I make ready; the girls help me with my regalia. I am already wearing white trousers and moccasins. Now I tie the black velvet sash around my waist, placing the beaded tassels at my right leg. The bandoleer of red beans, which was my grandfather's, goes over my left shoulder, the V at my right hip. I decide to carry the blanket over my arm until I join the dancers; no sense in wrapping up in this heat. There is deep, brick-red dust on the ground. The grass is pale and brittle here and there. We make our way through the camps, stepping carefully to avoid the pegs and guy lines that reach about the tents. Old people, imperturbable, are lying down on cots and benches in the shadows. Smoke hangs in the air. We smell hamburgers, popcorn, gunpowder. Later there will be fried bread, boiled meat, Indian corn.

My father is a man of great presence, a certain figure in the world. He is tall in stature, substantial, good looking; there is a style to his attitudes, a quality most often called charm. Rather, I believe, it is good will. He simply enjoys society and is most closely realized in it. There is a deep-seated, native vanity to him, an ethnic confidence, and it is attractive. It is good to see him here among our kinsmen. He has sure, easy access to the tribal

spheres of being. The old people recognize him; they are drawn to him; they are delighted to see him and call him by his Indian name.

Mammedaty was my grandfather's name; it means "sky walker," one who walks in the sky. In my mind's eye I see him in silhouette, at evening in the plain, walking against a copper sunset; so he lives for me in his name. Fifty years ago, more or less, he was given a horse on the occasion of the Gourd Dance. My father says: "Oh, it was a beautiful horse, black and shining. I was just a boy then, Jill's age or Brit's. His name, Mammedaty, was called out, and he was given that fine horse. Its mane was fixed in braids and ribbons. There was a beautiful blanket on its back."

We greet Taft Hainta, the leader of the Taimpe society. He embraces us. Jill gives him a hundred dollar bill. This, too, is traditional. Each year she has made the donation to the fund for the subsequent year's celebration. It is good that she gives a gift on her birthday. Taft sees that the girls are seated comfortably in view of the dance ground. It is not easy to find a good vantage point. There is a large crowd, and the shade is thickly populated.

Each year now it seems there are more and more young people in attendance. They come from far away, simply to be here, to be caught up in this returning, to enter into the presence of the old, original spirit that resides

For a time we stand on the edge of the crowd and watch, taking hold of the music and the motion. I see who is there, pick out friends and relatives. Fred Tsoodle is there always; he saw to my initiation five years ago. He counseled me, taught me how to take the steps, how to wear the regalia, how to hold the gourd and the fan properly. Now I look for him; it is a kind of orientation. My cousin, Marland Aitson, is across the circle. There is room next to him. I go there.

The sun descends upon the trees. There is a giveaway. People are standing in the circle, calling forth those to whom they will make gifts. I close my eyes, open them, close them again. There are so many points of color, like points of flame. The sun has drawn upon the place; it presses upon me. I feel the heat of it at my center. The heat is hypnotic-and the kaleidoscopic scene. It is as if I am asleep. Then the drums break, the voices of the singers gather to the beat, the rattles shake all aroundmine among them. I stand and move again, slowly, toward the center of the universe in time, in time, more and more closely in

There have been times when I have wondered what the dance is and what it means-and what I am inside of it. And there have been times when I have known. Always, there comes a moment when the dance takes hold of me, becomes itself the most meaningful and appropriate expression of my being. And always, afterward, there is rejoicing among us. We have made our prayer, and we have made good our humanity in the process. There are lively feelings. There is much good talk and laughter-and much that goes without saying. Here and there the old people play at words with the children, telling stories of this and that, of Creation and of the good things and bad things in the world-and especially of that which is beau-

The eagle is my power, And my fan is an eagle. It is strong and beautiful In my hand. And it is real. My fingers hold upon it As if the beaded handle Were the twist of bristlecone. The bones of my hand are fine And hollow; the fan bears them. My hand veers in the thin air Of the summits, All morning It scuds on the cold currents; All afternoon it circles To the singing, to the drums.



Chinese Shadow Theater by Bettie Erda

According to legend, Chinese shadow theater, or Pi Ying Hsi, originated in the court of the emperor Wu Ti. After the death of his beloved, the emperor was inconsolable, so his advisers devised a scheme to make her seem to reappear. They cast a shadow of the woman upon a screen, and the emperor, seeing her im-

age, grieved no more.

As early as the Han Dynasty (206 B.C.-A.D. 221) shamans and priests were creating flat, manipulable figures of paper and using them in rituals. By the Sung Dynasty (A.D. 960-1269) shadow figures were being used in plays. Later, puppeteers, traveling with traders and military invaders, introduced shadow plays into remote regions; shadow theater in Southeast Asia and even as far west as Turkey shows evidence of Chinese influence.

Succeeding generations of shadow players performed in palaces, temples, courtyards, and country laneswherever a crowd gathered. The Ch'ing Dynasty (1644-1912) witnessed the greatest development and popularity of Pi Ying Hsi. Although the tradition has declined somewhat, it is not dead, and Chinese throughout the world, as well as non-Chinese admirers, continue to follow this folk art.

Since shadow plays are based on the same plots, with the same symbolic underpinnings, as regular stage drama, they illustrate most aspects of Chinese theater. In both, stories of military conquests, government intrigue, lovesick maidens, and foolish officials are combined with Taoist and Buddhist legends in plots that often involve supernatural characters. Costume designs and makeup in puppet and live theater are identical and, in some cases, originated with the shadow figures.

Shadow plays have always served to educate as well as entertain. An individual's relationship with the gods in heaven and hell, with the animal kingdom, and with his fellow humans received continuing attention in the scripts. Just as the first shadow players used the medium for religious instruction, governments have also used it for political persuasion. In the People's Republic of China, audiences still delight in such ancient tales as The Crane and the Tortoise, but they also attend puppet plays about contemporary Chinese life.

Elsewhere in Asia, puppet theater also has a long history. In India, shadow plays of the Hindu epics date back to the pre-Christian era. The world's largest shadow figures, which still perform in Andhra Pradesh, influenced those in parts of Southeast Asia and Indonesia. Re-creations of the Ramayana legends, as well as plays based on local mythology, have been performed for centuries in Thailand, Cambodia, Malaysia, Java, and Bali.

Perhaps the most striking feature of the Chinese figures is their translucency, a feature that makes colored shadows possible. The early puppets had few parts and were made of thicker skins than those made in Peking in the late nineteenth century and featured on these pages. To make the figures, the puppeteers used donkey, cow, or goat hide (the ones pictured here are

made of donkey), which they first hammered thin and

soaked, then cut into separate pieces to form limbs,

head, and torso. The pieces were colored with natural dyes and coated with tung oil or lacquer. Finally, the parts were joined with thread or thong; wires at the neck and on each hand of the figure were attached to supports of reed or bamboo. The shadow master, holding the figures against a slanted screen, could then manipulate them.

Shadow figures in China were of eight different types that varied in size and thickness; the larger ones were designed for harvest ceremonies in rural areas,

the most delicate for performance at court.

Theaters for shadow plays consist of a simple cloth or paper screen, surrounded by a proscenium of red satin or wool highly decorated with embroidered flowers and symbols of good fortune. Behind this, coarse blue panels hide the puppets, the musicians, and the shadow master. A light is suspended over the shadow master's head; at his side, the figures hang from wires

in the order of their appearance.

Since the heads and bodies are separate, costume changes are easy, and many plays make use of numerous changes. Transformations from demon to human form, the progression of personalities from ordinary mortal to sainthood, even beheadings, can be seen on the lighted screen. Costumes, shapes of eyes, headdresses, and the color and design of face paint all have special meanings, making the characters easy to recognize: comics have a white eye mask, eunuchs have willow leaf eyebrows, beards indicate age or rank, warriors carry four banners, officials' hats are made with wide wings, court ladies have bound feet, nuns can be recognized by their patchwork robes (denoting poverty), and the emperor by his dragon coat.

The audience is also familiar with the traditional instrumental music and with the voices, all done by the puppeteer. Until recently, there was no written music and the style of accompaniment was handed down. Drums-large and small-gongs, brass finger-cymbals, a two-string violin called a hu-chin, and a flute provide

the music; a wooden clapper sets the time.

Naturally, a shadow play must be given in the dark; usually, the night-long plays are performed out-ofdoors by itinerant shadow masters, who carry portable curtained screens from festival to festival. In many cities, however, there are permanent theaters as

The theme of *The Chaos Box*, a shadow play of the Ming Dynasty (1368–1644), illustrates the concern of much Asian theater with philosophical and religious concepts. In the episodes we have illustrated, the reader can see the eternal struggle between the forces of good-here personified by the T'ien-shih, head of the Taoist faith—and those of evil in the person of Chin Hua, goddess of the demons. Her black magic is pitted against the power of the "original ether" (the chaos before creation of the world), as contained in the chaos box. Shadow theater can be enjoyed at many levels; a story such as this one, with its long, complex, and sophisticated script, was obviously designed for an adult audience, but its action and color have universal appeal, entertaining children and adults alike.

Because a Taoist priest wronged her three generations ago, Chin Hua, goddess of the demons, is angry with the head of the Taoist faith, the T'ien-shih. She has also received a message that the emperor is not attending to his duties, so she decides to send her demon army to earth to capture them both.

She instructs Centipede to wait beside Siu-hua-tze Temple and to seize the T'ien-shih. Scorpion is to wait in the brothel in Scratched Wall Street to hold him tight. Lizard is to wait in the Street of Bean Sprouts to hold him fast. Red Snake is to take three charms to ward off the T'ien-shih's magical powers and catch him when he stops. Other demons receive similar orders.



The demons, growing bored while they are waiting, assume human forms and become involved in strange and frightful ways with a number of men and women. After a series of skirmishes and adventures, they return to their pursuit of the T'ien-shih.

Centipede and Lizard make plans to capture the T'ien-shih. They will have the eunuch Lin Huan invite him to dine; then after dinner, Lizard, disguised as an acrobat, will catch the T'ien-shih.





In an earlier episode, Peach Ghost met Centipede, who told her that the T'ien-shih had beaten him with his magic seal, and also that all the demons, commanded by Chin Hua, were plotting against the priest. She has agreed to help catch him. Now, breaking in when the T'ien-shih is asleep, Peach Ghost attempts to steal the Chaos Box, thereby removing his power to capture demons. But the box presses her down, awakening the T'ien-shih, who reaches for his sword and tries to kill her. Peach Ghost is saved, however . . .



. . . when the Old Man in the Moon appears and announces that it is her fate to marry Godly Willow. At the command of the Old Man in the Moon, Godly Willow appears and he and Peach Ghost are told they are man and wife. Bidding them all good-bye, the T'ien-shih—still master of the Chaos Box—leaves to dine at Lin Huan's house.



After eating and drinking with the eunuch Lin Huan, the T'ien-shih appears bored. His host, therefore, suggests . . .



The T'ien-shih, however, is watchful and throws his chain, binding the demon.



Lin Huan objects, so the T'ien-shih, still holding the demon in his chain, orders Lizard to show his real self. He is then thrown into the Chaos Box.

. . . that his acrobats entertain them. Disguised in his human form, Lizard appears, does a cartwheel, and tries to blow his poison breath at the T'ien-shih.





Meanwhile, Centipede, anxious to free his friend, rushes in and fights with the T'ien-shih. They have a long battle, but finally he, too, is caught in the chain and thrown into the Chaos Box along with Lizard.



The emperor has received a report from one of his advisers—who has been traveling about the land—that the T'ien-shih is plotting against him.



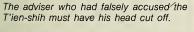
He accuses the T'ien-shih who, however, swears his faithfulness and tells of his many struggles against the demons.



Doubtful, the emperor opens the cover of the Chaos Box, and all the demons emerge, assuming human form. One after another, they kneel before the emperor and swear their innocence, asserting that the T'ien-shih has tricked him.



The enraged emperor demands proof that these are truly demons. At the T'ien-shih's command, Red Snake, Lizard, Centipede, and Scorpion revert to their demonic forms and leap forth, terrifying the emperor.







Order is restored throughout the empire as the demons go back into the Chaos Box, and the emperor returns the T'ienshih to his post on top of the mountain, giving him gold and doubling his salary.

Return of the Osprey

by Dennis Puleston

The ban on DDT has reversed the fortunes of a once-threatened bird of prey

Beginning in the mid-1960s, the steadily growing environmental movement began to achieve some notable victories in the battles against pollution, depletion of natural resources, declining populations of animals, and other ecological degradation. One particularly serious problem was the large-scale use of the persistent chlorinated hydrocarbon pesticide DDT. A worldwide contaminant, DDT had adversely affected a great many organisms, especially those animals, such as birds of prey, at the top of their food chains. Reproductive failure, eggshell thinning, and even fatal poisoning, all attributable to DDT, threatened the survival of a number of species.

As a result of local prohibitions and the imposition in 1972 of a national ban on the use of DDT, residues of this pesticide and its metabolites, DDD and DDE, are showing signs of declining in at least one bird species that had been seriously affected in the past. Osprey, or fish hawk, populations have been carefully documented for many years, and a significant decrease in the bird's numbers in many of its nesting colonies had been noted more than twenty years ago. Now a timely and important reproductive increase in one well-known osprey colony illustrates the importance of the battle against DDT.

During the 1930s and 1940s, Gardiners Island, lying off the eastern end of Long Island, was probably the site of the world's greatest concentration of nesting ospreys. Earlier in the century, visitors had estimated no more than 150 nests on the island, but construction and clearing operations on neighboring Plum and Shelter Islands forced many of the birds nesting there to move to Gardiners, which was free from such disturbance. Some birds probably moved there from the mainland for the same reason. Thus, in 1932, Capt. C. W. R. Knight, a well-known British authority on birds of prey, reported more than 300 osprey nests on Gardiners Island. Although no precise counts were made, other observers arrived at about the same total. On my first visit, in the late spring of 1948, I was ready to agree with the estimate of 300 active osprey nests on the island.

Gardiners Island, like Long Island proper, was created by glacial deposition; marine currents, ice, and glacial streams have all played a part in the upbuilding and the erosion of the island. Gardiners is roughly eight miles long, with a total area of 3,300 acres. At the north end lies Bostwick Meadows, an extensive area of low sand dunes and a salt lagoon; behind it is a forest of ancient oaks and other hardwoods. The remainder of the is-







SVEN GILLSATER; BRUCE COLEMAN, INC.

land consists mainly of gently rolling open grassland and heath interspersed with woodlots and a few ponds and swamps. Several large, shallow lagoons lie back of the shorelines, and the shores themselves are composed of beach sand and pebbles, with a scattering of large boulders.

The island was acquired in 1639 by Lion Gardiner, an English soldier of fortune. He paid "one large black dog, one gun, a quantity of powder and shot, and some rum and a few Dutch blankets" to the sachem of the friendly Montauk Indians. This transaction was later ratified by King Charles I, and Lion Gardiner became the first lord of the manor. The island has been privately owned and administered by Lion's descendants ever since, except for several periods during the 1930s and 1940s when it was leased to wealthy sportsmen as a hunting preserve. Some of the Gardiner family operated the island as a plantation, but in recent years there have been only three or four permanent residents, who serve as custodial and maintenance staff. The island is strictly protected from human intrusion. No one is permitted to land there without obtaining prior permission from the family, which is very solicitous of the ospreys' welfare. Although the family occasionally brings over hunting parties during the fall and winter, they do not remain there for extended periods.

The island's most remarkable ecological feature is the complete absence of predatory mammals, which may have adversely affected osprey breeding success in other areas. There is not one single raccoon, mink, fox, weasel, skunk, opossum, or rat to be found on Gardiners. They were probably exterminated many years ago when game birds were raised intensively on the island.

The ospreys had a wide selection for their nest sites on Gardiners Island: in tall trees, both dead and living; in a scattering of low dead cedars in Bostwick Meadows; on offshore rocks; on man-made structures, such as sheds, docks, and wreckage; and on the beach itself. Ornithologist Clinton G. Abbott in 1911 described twenty-two nests spaced fairly closely along the beach on the southwestern shore. In 1940 there were twenty nests on Cartwright Shoal, a low sandbar at the southern tip of Gardiners.

Thus, with fishing grounds close at hand, with no natural enemies, no human interference,



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Above the Everglades, an osprey carrying a captured fish heads for the nest where its offspring are waiting to be fed.
Ocean fish are a primary food resource for this bird of prey.





APPLIED OFF

No one is permitted to land on Gardiners Island without the consent of its owners, a policy that minimizes human disturbance of ospreys nesting there. Two young nestmates (right) bristle at the approach of the photographer.



and plentiful nest sites available, the Gardiners ospreys have had optimum breeding conditions. In the 1940s, each active nest averaged more than two fledglings; in 1941, for instance, an average of 2.2 offspring were banded for each ground nest visited.

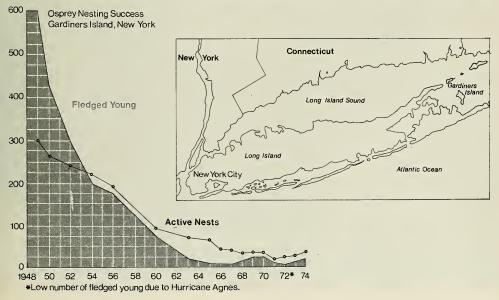
In 1948 a decline set in, both in the number of active nests and in the reproductive success of each active nest, and by the mid-1950s it had reached crash proportions. In 1952, for example, only eight nests were occupied in Bostwick Meadows, where ten years before there had been thirty to forty. The number of fledged young reached its lowest point in 1965 and 1966; in each of those years only four young were fledged from fifty-five to sixty nests—an average of only 0.07 young per nest.

Since 1966, however, fledgling totals have increased. The most dramatic rise occurred in 1974, when twenty-six young were fledged from thirty-four nests, compared with eighteen young from thirty-one nests in 1973. On Long Island itself the reproductive picture also brightened considerably, and several new nests were occupied by returning ospreys.

Studies of osprey eggs revealed the cause of these remarkable population trends. Unhatched, overdue eggs collected on Gardiners Island in the mid-1960s were analyzed by gas chromatography. One egg contained 13.8 ppm (parts per million) DDT and its metabolites; others had only slightly lower concentrations. An egg laid in 1967 had 11.3 ppm, and in 1969 two eggs had a total of 13.7 ppm, together with 0.28 ppm of dieldrin, another chlorinated hydrocarbon pesticide. Fragments of eggshells and dented eggs found in many nests during those years indicated that the birds were unable to mobilize sufficient calcium for healthy eggshell development. This is one of the important symptoms of DDT ingestion in a female bird. At any one time during this period, at least a dozen thin-shelled eggs that would not hatch could be found on the island. But in early June of 1974, when incubation was well under way, not a single cracked or broken egg could be found.

Gardiners Island has been sprayed with DDT only once. This was in 1957, when the United States Department of Agriculture launched an ill-advised and totally futile effort to prevent gypsy moth infestations in the Long Island area. The Suffolk County Mosquito Control Commission, however, routinely aerially sprayed DDT during every spring and summer from the late forties until 1966, when members of the Brookhaven Town Natural Resources Committee (who later formed the nucleus of the Environmental Defense Fund) brought a lawsuit that succeeded in bringing an end to this practice. DDT was also proving less effective for farm applications in other areas, so pesticide residues in the local environment were expected to decline steadily from then on. The nationwide ban should have greatly accelerated this declinewith a concomitant increase in the populations of species that had been affected by DDT.

This has indeed been the case. As DDT residues have gone down, we are beginning to see upward trends in the animal populations that are highly susceptible to that contaminant. In the case of the blue crab (Callinectes sapidus), for instance, DDT concentrations of a few parts per billion are toxic to the larvae, and



from the late fifties until the early seventies the blue crab almost vanished from Long Island's Great South Bay, where formerly it had been abundant. In the 1960s, however, it began to reappear in Long Island waters, and in 1974 it was once again a plentiful and important food resource.

In the case of the osprey, with its relatively slower life cycle, recovery will be more prolonged. Yet the findings on Gardiners Island in 1974 give reason for optimism. Jack Foehrenbach, senior analytical chemist with the New York State Department of Environmental Conservation, analyzed an overdue egg I brought back from the island last year and found 3.59 ppm DDT and its metabolites, plus 0.42 ppm dieldrin, also recently banned by federal action. A dead three-day-old chick that I found in a nest contained only 1.34 ppm DDT. These are promising reductions from the findings of ten years

ago. The noted ornithologist Dr. Joseph Hickey predicted some years ago that the osprey would soon disappear as a breeding species in the northeastern United States. At that time, no one would have disputed him because DDT was still in heavy use. But if the current ban is maintained, we may well find in the next few years that these latest findings in the osprey-DDT relationship are indeed the beginning of a steady upward trend. Providing we do not introduce some new, toxic material into the marine environment and continue to give the osprey full protection, this splendid bird could again become a common sight along the Atlantic seaboard.

Ground nests (this one is in the Everglades) are common on Gardiners Island because of the absence of mammalian predators. The birds also nest in trees and on man-made structures.





Survivors from the Good Old, Old, Old Days

by Niles Eldredge

A number of animals, whose pedigrees stretch back millions of years, seem to have escaped the usual dilemma of evolution or extinction

The most unchanging aspect of life is change itself. Yet a number of animals, known as "living fossils," have persisted essentially unchanged for hundreds of millions of years. Such an animal is the North American horseshoe crab, Limulus polyphemus, which occurs commonly along the eastern seaboard of the United States and around the shores of the Gulf of Mexico. This creature is not a true crab; it is the sole modern representative of a group, distantly related to spiders and scorpions, that was abundant in the Paleozoic seas. Some other living fossils are the nut clam, Nucula; the brachiopod Lingula; and the lizardlike reptile Sphenodon, perhaps the most famous vertebrate living fossil.

To qualify as a living fossil, an animal must have certain credentials. It must represent the persistence, in nearly unchanged form, of an ancient and comparatively primitive structural type. It must have fossil relatives that date far back to a remote geologic period—as close as possible to the 600-million-year-old beginnings of the fossil record of complex animals. (Fossil horses, which are essentially modern in structure, exist in Pleistocene rocks that are more than a mil-

lion years old, but a few million years just are not enough; the true living fossil's pedigree must be tens, or preferably hundreds, of millions of years old.) And a living fossil should have no—or at best, only a few—close living relatives. In addition, if the creature exists in a restricted area, so much the better.

Because animals with these qualifications raise many provocative (and largely unanswered) questions in evolutionary biology, they have long excited the interest of naturalists. Why have some organisms evolved so slowly, if at all, while the rest of life on earth has been involved in the cycle of evolution and extinction? Why do comparatively primitive structural types frequently seem to outlast their more advanced relatives, with the result that most classic living fossils have few, if any, even moderately close living relatives?

A structural type is simply a plan of body organization. All members of a species share a basic body plan. But "structural type" can also be applied to large groups of related organisms. All mollusks, for instance, share a basic, discernible body plan that differs drastically from the basic plan of organization of arthropods, vertebrates, and indeed, all other known animal phyla. The old notion of the scale of nature-the gradation of organisms from simple to complex-was based on the comparison of body plans of the major animal groups. From this point of view, Virtually the only difference between the modern horseshoe crab, Limulus (right), and its 300-million-year-old fossil relative, Palacolimulus (below), is one of size adult living horseshoe crabs are at least five times larger.



60







G. ROBERT ADDINGTON

The multichambered nautilus (left) is found today swimming in the deep ocean waters of the Indo-Pacific region. But its 90-million-year-old fossil relative Eutrephoceras (above) lived in shallow waters that once covered most of continental North America. This fossil was found in North Dakota.

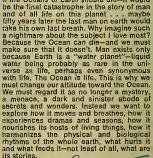


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all the phyla are living fossils, but the simplest organisms—the unicellular protists, the tissueless multicellular sponges, and the simple-tissued coelenterates, for instance—are the best examples of living fossils because they are generally thought to represent a more "primitive" type of body organization than "higher" groups such as the mollusks, arthropods, and vertebrates.

One of the ironies of the early post-Darwinian era of evolutionary thought stemmed from translating the progression from simple to complex in the scale of nature into a direct progression of primitive to advanced, hence, of inferior to superior. The irony, of course, is the persistence of the presumably inferior body plans. If evolution only produces organisms superior to their antecedents, hasn't enough time elapsed for all the inferior primitive types to have disappeared, losers in the evolutionary race? But calling an entire phylum-like the spongesa living fossil is also inexact, for we can readily imagine a large group persisting through the normal process of the extinction of its older members only to be replaced inevitably, as time elapses, by the evolution of newer species. Therefore, we should continue to restrict the notion of living fossils to species that closely resemble ancient species because it is on this low species level in the hierarchy of organisms that we must confront the phenomenon of evolutionary nonchange.

The importance of the qualification that living fossils be bereft of close living relatives is best illustrated by the disparate treatment usually accorded two modern clams, Nucula and Neotrigonia. Neotrigonia (meaning recent Trigonia) is one of the better-known examples of a living fossil. First known from an abundance of Mesozoic fossils, the trigonids-a diverse array of clams that made up an entire family-were thought to have disappeared from the fossil record at the close of the Cretaceous period. Long after they were discovered as fossils, living specimens of *Neotrigonia* were found along the southern coast of Australia. Somehow, one small group of these clams, whose heyday was over 90 million years ago, managed to hang on.

aged to hang on. In contrast, Nucula is found burrowing into the mud of nearshore marine habitats virtually everywhere. Nuculoid clams, first encountered in Ordovician rocks that date back nearly 500 million years, are traditionally acknowledged to represent a more primitive state of "clamness" than the trigonids. Although trigonids have recognizable relatives that are perhaps 400 million years old, they did not become fully trigonid until the Mesozoic era and are a much younger group than the nuculoids. Nuculoid anatomy, as judged from external form and internal muscle scars and hinge teeth, has hardly changed at all from Ordovician times. Indeed, the shells of modern Nucula resemble those of Ordovician nuculoids more closely than today's Neotrigonia resemble Cretaceous trigonids. Yet Nucula is not cited as often or considered as good an example of a living fossil as Neotrigonia. Why not? Presumably because the abundance of individuals, the moderate diversity in terms of the number of extant species, and the broad geographic distribution of modern nuculoids disqualify this clam as a living fossil. Nucula is

totally satisfactory living fossil.

Evidently, then, to be a good example of a living fossil, a creature should be a lone survivor, precariously clinging to its existence long after all its close relatives, unable to make it in more modern times, have died off. To this end, it helps if the organism has a relict distribution—that is, if it is found in only a small portion of the world, in a habitat whose extent is greatly reduced from the area of its former, farflung stomping grounds.

too successful, and a successful

clam that happens to belong to a

primitive group doesn't make a

Sphenodon, a reptile that lives exclusively on a few islands off the coast of New Zealand, meets

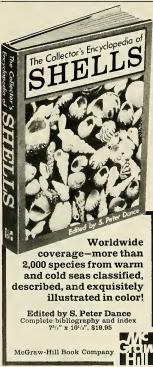
all these requirements. This animal is the sole survivor of a moderately diverse Mesozoic order of relatively primitive reptiles. And, perhaps best of all, Sphenodon is confined to a single area that is vastly smaller than the worldwide range of its ancient relatives. It presumably hangs on to life only because there are no competing lizards in New Zealand.

The invertebrate organism that best fits this restricted set of criteria for a living fossil is the mollusk Neopilina. Discovered in the 1950s in dredge hauls from the abyssal depths of the ocean, Neopilina is the only living member of the Monoplacophora, a class of mollusks generally considered to be the most primitive. This class, which first appears in Lower Cambrian rocks, was thought to have become extinct by the end of the Middle Devonian period. The simple spoonshaped shell of Neopilina is virtually identical to that of the Silurian genus Pilina, a limpetlike reef dweller. But Neopilina does not cling to a reef in the intertidal zone. It exists exclusively on the deep floor of the ocean-a habitat exploited by few other mollusks, indeed, few other animals of any class. Neopilina thus occupies a safe place free of competition from more highly evolved mollusks.

It is impossible to judge whether or not these primitive mollusks have always lived in deep ocean basins or whether they took a dive in the Silurian period because no fossil record exists of deep ocean basin habitats older than the Jurassic. In any case, Neopilina admirably fits the most stringent requirements for a living fossil: a small group of closely related, primitive species of truly ancient pedigree that hangs on to life in the refuge of the abyss.

How can such basic types as *Neopilina* and other living fossils persist unchanged? Why do they tend to hang on for so long? Why do so many of these persistent organisms seem primitive when compared with their known





fossil relatives? And, finally, why are these creatures frequently orphans without any close modern relatives?

In thinking about modern organisms, it is a truism to assume that all species are well adapted to their environments. In these days of eco-consciousness, everyone knows that each species has its own niche, which consists of all the physical, chemical, and biotic influences-such as temperature, pH index, predators, and food resources-with which that species copes, utilizing its own peculiar behavioral and anatomical properties. When niches are thought of in this fashion, it is clear that no two individuals, let alone two separate species, share exactly the same niche characteristics. That much we know, but there is a tendency to forget that our lifetimes represent as thin a slice of geologic time as, say, seventy-five years in the Silurian period. So it is reasonable to assume that Silurian species were as well adapted to their niches as are we and our fellow creatures of the modern biota.

Niches are conservative, and species, if they persist at all, tend to do so unchanged as long as their habitats remain accessible to them. Given a habitat that persists almost unaltered over a long period of time and a species adapted to it, there are only three possible courses for the species to follow: it will either disappear, evolve into something new, or persist in a form similar to its original one. Instances of this latter kind of morphological stability, in which a species persists essentially unchanged for perhaps as much as five or ten million years are currently being carefully documented by a number of paleontologists. Such longterm stability makes one wonder why evolution was not basically over with soon after the first appearance of life on earth. In a sense, it was, since all of the phyla of the complex, multicellular animals that appeared near the beginning of the Cambrian period originated almost immediately. But evolution proceeds on

the species level, and no living metazoan species (those having differentiated cells) inhabited the Cambrian world. Extinction has claimed the earliest metazoans; indeed, it has claimed the vast majority of all the species that have ever lived on this planet.

So far I have argued that if a species survives, it tends to do so unchanged. Also, the chances of a species persisting over the truly long periods of time required by living fossils are almost nil. But it happens that the chances for survival are not equally distributed among all species or even among different species that are closely related to one another and belong to the same order or even the same family. Some species are specialists, adapted to a highly specific set of conditions that they require for continuation, while other species are tolerant of a much broader range of environmental conditions. Evolution is essentially opportunistic, and wherever a set of optimal, stable, predictable conditions develops-for example, a seaway with little daily or even seasonal fluctuation in salinity, temperature, or wave action-the locale will soon be populated by a diverse array of species exploiting the subhabitats that such a favorable environment offers. These species frequently develop anatomical and behavioral modifications of their ancestral condition, the better to exploit the advantageous conditions of the habitat. Specialist species thus often look and act more highly evolved than their forebears and are commonly cited as evidence that evolution produces biological improvement.

Nonspecialist, or generalist, species, on the other hand, which occupy unpredictable environments with a wide variety of daily and seasonal changes, must be more flexible. They do not concentrate too much on one particular food item or get too used to a certain comfortable temperature. This kind of species is comparable to the person who is a jack-of-all-trades but master of none. Limulus, the horseshoe

crab, is such a generalist species. It is a moderately good swimmer, walker, and burrower. While some true crabs are better walkers or better burrowers or better swimmers, I know of no crab that can perform all three functions as well as *Limulus*.

Generalists cannot stand too much competition, so they live in habitats where most other species are also compelled to be generalists. In addition, they do not show much diversity; that is, at most only a few closely related generalist species will be found living together at any one time and place. The horseshoe crab is a single, far-flung species, which ranges from Nova Scotia to the Yucatan. Its only close relativesthree or four species that are dead ringers for the North American species-live in different parts of the western Pacific and Indian oceans.

Competition between closely related, relatively specialized species frequently leads to a subdivision of resource space. Various species somehow manage to live side by side, dividing up the resources and concentrating on different aspects of the environment, such as different food items. In the process, their morphologies and behavior patterns become even more specialized. Darwin first noted this specialization phenomenon while observing the native finches on the Galápagos Islands. Generalists, on the other hand, tend not to develop new anatomical and behavioral characteristics in the process of speciation. Instead, they continue to look and behave like their ancestral species. Competition between closely related generalist species thus usually results in the replacement of one species by another. That is why generalists appear to evolve so slowly and to have a lower rate of speciation. The ecological strategy of generalists acts as a damper on speciation because relatively few generalists will occupy the same amount of habitat space that a larger number of specialist species can populate.

Given these arguments, what



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happens when the environment is radically altered? To use a human analogy, think of a highly educated specialist in, say, banking and a jack-of-all-trades handyman. The first may earn \$50,000 a year and be considered a success, while the other earns far less and may be deemed a failure. The banker lives in a generally predictable environment and can count on a regular paycheck: the handyman lives catch as catch can. This may go on for many years, until, bang-a depression hits. The banker may then lose his job, but the handyman, while also hit, can hang on and continue to do pretty much what he has been doing all along. The analogy is not perfect, but there is a wealth of evidence from both the fossil record and from the observation of modern living fossils, to show that generalists-the "failures" of the moment-are, in fact, the long-term winners. Survival is, after all, what life is all about.

At this point we can say that relatively unstable and unpredictable habitats, which persist through time, should be populated by generalists. In the marine realm, by far the most unstable, varying, and even unpredictable environments are the intertidal and barely subtidal zones near the shore. They are subject to great variations in temperature, salinity, amount of dissolved oxygen, presence or absence of water, and a host of other factors. Conditions are far more stable below the wave base out on the continental shelf. where even the sediments on the ocean floor are seldom disturbed. It is therefore not surprising to find such ecological generalists as Limulus and other marine living fossils inhabiting the near-shore environment.

Not all living fossils are obvious generalists, however, and the ecological generalist argument is not universally applicable. The reptile *Sphenodon* and the mollusk *Neopilina*, for instance, live in refuges safe from competition and possible extinction by less primitive and perhaps more efficient organisms, especially close relatives such as lizards and gastropods, respectively. The case of *Sphenodon* is apparently simply

an instance of a favorable habitat; the case of *Neopilina* is a little more complex, since this organism had to become adapted to the harsh, rigorous environment of the deep ocean floor. But most examples of living fossils do seem to be ecologically generalized species when compared with their closest known living relatives.

Why should comparatively primitive plans of body organization lend themselves to a generalist survival strategy? Actually, they don't necessarily. Primitive is a relative term used to describe the condition of the most recent common ancestor of a given group. Five digits on the terminal part of the forelimb is the primitive condition for mammals because the common ancestor of all mammals, whatever it was, must have had five digits. We presume this must be so because all, most, or some of the constituent taxa of most orders of mammals have five digits on that part; those mammals that have fewer digits frequently show signs of having had more in their early embryonic stages. Finally, reptiles and amphibia, close relatives of mammals, also typically have five digits; those with fewer, likewise seem to be later developments. In this respect, human hands are primitive, but they are also specialized by virtue of long grasping fingers and an opposable thumb.

If after a given group first appears, it undergoes a significant amount of evolutionary diversification, the greater part of this change inevitably involves invention and elaboration of structure and behavior, not to improve on the ancestral adaptation to the original niches, but rather to exploit new environmental possibilities or invade new niches: in short, to specialize. Most adaptive radiations or truly large-scale examples of diversification of a single evolutionary stock, as well as the more modest bursts of organic diversity, involve the development of side branches of stocks that are more anatomically and ecologically specialized. Thus, the relatively more generalized members of a group are usually, although not invariably, those that retain the primitive unelaborated anatomy and behavior. That is why most long-lived structural types tend to be relatively primitive, and why many primitive types, relative to other members of their own groups, are ecological generalists and thus more likely to enjoy a somewhat higher probability of survival.

Some bona fide living fossils-Sphenodon and the clam Neotrigonia, for instance, which lack close modern relatives-belong to groups that were considerably more diverse in remote times. But there are other living fossils-Limulus and the mollusk Neopilina being two-that belong to groups that never attained any appreciable diversity. In these instances, we are not dealing with extinctions that weeded out relatives but rather with the nonevolution of many relatives in the first place. Particularly in the instance of the horseshoe crab, relatively little was accomplished in terms of developing new and different plans of body organization. So a final question is, why? Why didn't the horseshoe crab move from its coastal habitat into another environment and then specialize and thus diversify?

This kind of question-why something did not evolve-is both intriguing and difficult to answer. Here again, the notion of competition seems to offer a clue. Hindsight indicates that the general body plan of true crabs proved more adaptable and more modifiable than that of the horseshoe crab, thus allowing specialization in such all-important functions as feeding and locomotion. True crustaceans, not horseshoe crabs, were accordingly able to exploit microhabitats, and they therefore diversified far more than the horseshoe crab ever could. As I said earlier, Limulus walks, burrows, and swims pretty well, and no true crab known to me can do all three as well. But Limulus cannot burrow as efficiently as the mole crab Emerita or walk or swim as well as some other crab species can. Without the competitive presence of the crustaceans, perhaps the horseshoe crab would have specialized and diversified more than it did. But if it had specialized, it might not have survived as long as it has.

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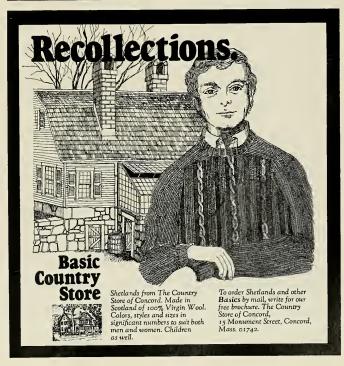
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A Plant of Ill Repute

Shunned for its flagrant odor, garlic may be tamed with gentle handling in the kitchen

"We absolutely forbid it entrance into our Salleting," wrote Sir John Evelyn in a late seventeenth-century treatise on the lore and botany of salad (sallet) herbs and greens. "By reason of its intolerable Rankness, and which made it so detested of old; that the eating of it was (as we read) part of the Punishment for such as had committed the horrid'st Crimes. To be sure, 'tis not for Ladies Palats, nor those who court them, farther than to permit a light touch on the Dish, with a Clove thereof . . ."

Evelyn, a leading member of the Royal Society, an authority on gardening, and a famous diarist, might, orthography apart, have written that attack on garlic yesterday. He, like most English speakers now alive, would probably still claim to abhor the pungent odor of the bulb of Allium sativum. Alliophobia, the unreasoning fear of garlie, is in fact one of the few distinctive attitudes toward a foodstuff that has continued unchanged since the earliest days of Western history. The Greeks would not permit garlic eaters to enter the temple of Cybele. Shakespeare advised actors to abstain from this always maligned member of the lily family when they are to "utter sweet breath."

Garlic has been used to start moles from their holes. Galen prescribed it as an antidote to poison. In 1722, during a plague epidemic in Marseilles, thieves who had plundered the bodies of dead victims of the dread disease without falling ill attributed their immunity to a decoction of garlic thereafter known as "four thieves' vinegar" and employed as a feb-

rifuge. Garlic juice laced with honey or sugar was once a remedy for bronchial complaints, and no doubt it did clear people's throats and sinuses, just as soupe à l'ivrogne ("drunkard's soup") must have been an effective cure for hangovers in France.

No one who has ever bitten a raw clove of garlic can possibly speak of the experience without some lingering awe. The ancients expressed their shock and wonder in colorful terms. Today, we know that the jolt comes from a volatile oil familiar to chemists as diallyl sulphide. And we have also learned to tame this fierce natural product in our kitchen laboratories.

Any kind of cooking dissipates some of garlic's strength, but prolonged exposure to high heat makes the cloves turn bitter. For this reason, we add garlic at the end when we sauté or else we remove it from the fat after a short time, as soon as it has imparted a reasonable amount of

Whole cloves exude much less oil than cloves shredded in a garlic press. Chopped cloves fall somewhere in between on the pungency scale as do cloves smashed with the flat of a knife blade.

This obvious principle—the less you do to garlic the less it does to you—is behind those famous stews of the south of France that contain literally dozens of cloves of garlic. Long, slow braising transforms each clove into a soft, harmless, pleasantly edible vegetable with a nutty taste. Whence the culinary designation *en pistache* for a leg of lamb presented with fifty garlic "pistachios" (see recipe below).

This process is not a diabolical plot contrived by surly French peasants lusting for revenge on the outside world. It really works. After two hours in the oven, the garlic can be served as calmly as peas. Only a civilized residue of garlic flavor remains.

This immediately recognizable taste, which can be distinguished with ease from the tastes of such other edible alliums as onion, leek, shallot, and chive, is the only plausible explanation for the worldwide spread of the garlic plant from its putative wild home on the steppes of Kirghizia in Central Asia. The migration began before the construction of the pyramids in Egypt, for Herodotus relates that the men who built the pyramids ate garlic, not as a food, but as a relish. Even if Cheops's slaves had known that garlic contains ten times as much protein per unit weight as carrots, they still would not have gobbled garlic by the pound. The flavor was sufficient, and for obvious reasons, it had to be.

Garlic's remarkable taste was enough to prompt cultivation in nearly every part of the world, from Italy, where garlic, hot pepper, and oil flavor "teamsters'" spaghetti, to China's Szechuan province, where eggplant and garlic are a favored combination.

In northern countries, however, where extreme flavors have never found much of a welcome, garlic has usually had the status of an unassimilable immigrant, too noticeable, awkward at parties, tolerated at a distance, and only occasionally sought after to provide a touch of the exotic, mostly in garlic bread.

We may also speculate that garlic has primarily flourished in warm countries because it grows best and most abundantly in direct sun. But even in temperate climates, garlic will grow nicely if planted in the early spring.

Set individual cloves (officially known as bulblets) in light sandy soil of pH 5.5 to 8.0 at a depth of about 1½ inches, 6 to 8 inches apart. Fertilize with compost or

manure. When the plant reaches a height of 6 inches, apply 5-10-5 fertilizer, about 3 ounces per 10-foot row.

The bulb develops entirely underground and is ready to pull when the flat, green leaves wither and yellow. This will occur sometime between July and early fall, depending on climate. To speed ripening, bend the tops of the plants over to the ground late in the season.

After the harvest, braid the leaves together and hang the bulbs in a well-ventilated place for several days to dry. Dried garlic will keep at room temperature for up to a year. Strings of garlic are not only attractive but also guaranteed to keep werewolves from your door, according to a tradition never adequately refuted.

Another advantage of growing garlic at home is that you will be able to enjoy the sight of its delicate, whitish flowers. The young flower head pushes upward atop a smooth, solid stem. At first, it is encased in a papery, sword-shaped spathe, or sheath, that drops away to reveal flowers mixed with edible bulblets. The spathe may be responsible for the naming of garlic, which means "sword onion."

Should you forget to harvest the mature plant, it will survive the winter and bloom again the following year. Garlic is a perennial. And there is probably no need to worry if your crop fails, for garlic farmers, mostly in California, produce about 200 million pounds each year. Since an average clove weighs 1/16 ounce, that adds up to a total annual commercial yield of approximately 51 billion cloves.

If we assume that Americans actually consume this titanic output, then there must be a quiet shift in national taste going on, away from garlic fear and toward

alliophilia. The official statistics work out to more than 200 cloves per year per person. Since this garlic orgy has escaped public notice, we are all apparently so habituated to the odor of garlic breath that we no longer notice it. But what of foreign visitors? Surely, good manners require that we control the mounting levels of diallyl sulphide in the atmosphere so that tourists are not overcome by fumes to which we have become accustomed. The classic method for fighting garlic (and onion) breath is to chew parsley. Wash garlicky hands in cold water, rub with salt, rinse, then wash with soap and warm water. Repeat if necessary.

If foreigners still complain about American garlic pollution, there is nothing left but to quote them this quatrain from *The Englishman's Doctor* (1609), by Sir John Harrington:

Sith Garlicke then hath powre to save from death, Beare with it though it make unsavory breath. And scorne not garlicke like to some that think It only makes men winke, and drinke, and stinke.

Leg of Lamb en Pistache

- 3 slices prosciutto (about 2 ounces)
- 1 medium onion, peeled and thinly sliced
- l large carrot, peeled and cut in thin rounds
- 1 6-pound leg of lamb, trimmed and with shank removed
- 2 tablespoons goose fat, duck fat, or lard, melted Salt and Pepper
- 2 tablespoons flour
- 1 cup dry white wine 2 cups beef or veal stock
- 50 cloves garlic, peeled
- 1 bay leaf tied up with 2 parsley stems, 1¹/₄-inch strip of dried orange peel, and 1 sprig thyme

(or dust bay leaf bouquet with 1/4 teaspoon dried thyme)

- 1. Use a roasting pan or Dutch oven just large enough to hold the lamb. Cover the bottom of the pan with the prosciutto, onion slices, and carrot rounds. Set the lamb over the vegetables, skin side down. Season with salt and pepper. Drizzle the fat or lard over the meat. Cover the pan and let its contents sweat over medium-low heat for 30 minutes.
- Remove the lamb and the prosciutto from the roasting pan. Dice the prosciutto. Preheat oven to 350 degrees.
- 3. Whisk the flour into the vegetable mixture in the pan. Continue whisking over mediumlow heat until the flour takes on a nut-brown color. Add the wine and stock and mix well. Strain the resultant liquid through a fine strainer and return it to the empty roasting pan. Then put in the diced prosciutto and the lamb. Sprinkle the garlic cloves over the lamb. Set the bay leaf bouquet in the cooking liquid. Bring the liquid to a boil, cover the pan with a sheet of alumimun foil and then the lid, and set it in the lower third of the oven for approximately two hours or until very tender. Turn and baste the lamb every half hour.

To serve, drain the lamb and set it on a serving platter. Discard the bay leaf bouquet. Then degrease the cooking liquid and pour it, with the garlic cloves, over the meat. The cloves will now taste nutty. The lamb can be reheated in its cooking liquid quite successfully.

Yield: Six to eight servings.

Raymond Sokolov is a free-lance writer and food columnist.





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Here Come the Clones

Genetic engineers are making us an offer that perhaps we should refuse

The newspapers are full of stories describing the revolution about to be wrought by genetic engineers and other new breeds of biologists. Who are these people? What are they trained to do? What kind of impact are they likely to have on the world? And should we view their operations with approval or alarm?

We must begin with the realization that man has long been manipulating the genetic constitution of useful plants and animals. Almost all of the strains and varieties utilized in current agricultural practice represent the end points of persistent attempts to improve the breed. The main technique employed so far has been the selection and controlled sexual hybridization of desirable stock. When done judiciously, this can be a powerful procedure. It has, for example, led to the development, from a single ancestral type, of all the current breeds of dogs-from the poodle and Chihuahua to the Great Dane and Saint Bernard. Highvielding hybrid corn and socalled miracle rice and wheat have also been developed by this ancient method. Even the molds that produce penicillin and streptomycin have been improved by selection and controlled mating. Today, a world desperately short of food depends in part on the feverish activities of plant breeders, who strive to produce new strains of wheat and other highyield crops that will be resistant to wilts, smuts, rusts, and other bacterial and fungal diseases.

In this battle, man is at a serious disadvantage, since those microorganisms that have a rapid life cycle can mutate and produce new pathogenic varieties more quickly than experimenters can select and breed new, resistant types of the slower-developing, high-yielding plants. Hopefully, the newer knowledge of biology, and of molecular genetics in particular, may restore the advantage to man.

In animal biology and in fields associated with public health, some of the achievements of recent cell and molecular biology have been noteworthy. Consider, for instance, the technique of cloning, already a reality with various laboratory animals. This procedure for producing many genetically identical individuals depends on the fact that the fertilized egg of most animals, on its way to developing a differentiated embryo, first forms a hollow ball of cells called a blastula. The individual blastula cells, or blastomeres, can be separated from one another without too much injury by the use of selected chemical and mechanical techniques. If this is done early enough in the life history of the embryo, cellular differentiation will not as yet have occurred; each blastomere will be completely "embryonic" and as capable as the fertilized egg itself of producing an entire new or-

ganism. With lower animals, cloning can be accomplished merely by cultivating the blastomeres in an appropriate medium; with mammals, the blastomeres must be implanted individually in the uterus of the natural or a surrogate mother, where they will develop into normal, genetically identical embryos. The latter technique is of great value in rapidly multiplying the numbers of individuals with desirable genetic constitutions. In the dairy industry, for example, it can lead to the swift spread of genes from the most desirable bulls and cows. It has even been suggested that cloning might be applied to humans. We ought to think seriously about this suggestion and attempt to formulate laws to regulate the practice, for while human cloning is not yet technically feasible, there is every reason to believe that it soon will be.

Since almost all of the genetic information encoded in the cell resides in the nuclear DNA, cloning can be accomplished by transplanting naked nuclei instead of entire cells. In such an experiment, the receptor may be either a fertilized egg or an ordinary body cell. First, the nucleus of the receptor cell is destroyed, either mechanically or by controlled radiation, without destroying the capacity of the rest of the cell to continue the various life processes. Next, a nucleus extracted from another cell of a desired genotype is microinjected into the enucleated receptor. Under appropriate conditions, the receptor cell will then develop into a normal embryo, its genetic characters being conferred almost entirely by the DNA of the introduced nucleus. This would obviously be the preferred method of genetic engineering if an egg or other whole cell introduced into a uterus for cloning were rejected by the mother.

But even this means of nuclear transplantation seems crude in comparison with more sophisticated techniques now being developed. One new method involves the isolation from donor cells of individual chromosomes and their introduction into receptor cells. This technique takes advantage of the stage of nuclear division at which the DNA of the nucleus has been condensed into short chromosomes lined up on the equator of the cell. If a cell is broken open at that time, the chromosomes can be separated from the rest of the cell material TRAVEL THE WORLD OF LINDBLAD



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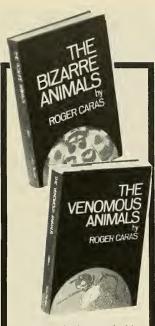
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Now at your bookstore, or send check or money order to BARRE/WEST-OVER BOOKS, a division of Crown Publishers, 419 Park Ave. South, New York, N.Y. 10016 by gentle centrifugation, in which cell particles are deposited according to their density. Individual chromosomes, however, differ in size and density themselves; by careful centrifugation in a solution of graded density, one chromosome can be separated from another.

When this experiment is done with many cells, controlled so that they enter the crucial phase of nuclear division synchronously, large numbers of identical chromosomes can be obtained. As we begin to learn which chromosomes bear particular genes, we may be able to select at will, for introduction into a receptor cell, those groups of genes whose genetic constitution we wish to vary. In some experimental systems, this basic operation has already been carried out. Here, too, it is just a matter of time before the procedure may be used on human beings.

The genetic engineering techniques described so far involve progressively smaller and more precise intervention into the developmental process. Cloning operates at the cell level, nuclear transplantation involves only that portion of the cell carrying the major part of the genetic material, and chromosomal insertion deals with that part of the nucleus bearing the genes. The ultimate precision of genetic engi-neering is realized when single genes-or at most, small clusters of genes from a particular chromosome-are multiplied, purified, and then introduced into the cell in which they are supposed to act. In this process, bacteria, whose genetic apparatus is comparatively well understood and amenable to manipulation, are used as a "farm" in which to grow many copies of a desired gene.

Let us follow in detail this particular use of genetic engineering to see how a biochemical lesion caused by a mutation might be corrected. Our example will be a hereditary human disease called galactosemia, in which infants are made seriously or even fatally ill by ingesting milk. Milk contains lactose, or milk sugar, which is split into two simpler sugars, glucose and galactose, during the process of digestion. In the body,

galactose is normally converted first to galactose-1-phosphate, then to other compounds. In galactosemic infants, a mutant gene controls the production of an enzyme that is incapable of further transforming the galactose-1-phosphate. The galactose-1-phosphate, accordingly, accumulates, and when it reaches high concentrations, it damages or kills the infant's cells.

The potentially damaging effect of this mutant gene may be circumvented by putting the infant on a diet free of milk and other foods containing galactose. Later on in life, when bodily development is largely complete, restrictions on diet may be relaxed. This regimen, while it avoids the deleterious effects of the disease, does not cure it. A more ambitious technique involves the proliferation in bacteria of the gene controlling normal galactose-1-phosphate metabolism, followed by the introduction of these genes into human cells.

The chromosome of a bacterial cell is a huge circular loop about 1 millimeter in length, which is about 1,000 times the length of the entire bacterial cell. This giant circular chromosome contains some 5,000 genes, each coding for a protein. Inside the bacterial cell there usually are other, smaller loops of DNA that belong either to viruses or to smaller, independent parts of the bacterial genetic material. The small, viral DNA loops divide independently of, but usually synchronously with, the other loops. Sometimes, during synchronous replication, the DNA strands of the smaller viral loops join with the DNA loop of the large bacterial chromosome to produce a form, consisting of one large and one small circle, that resembles a figure 8. Later on, another such random crossover event may again liberate an independent small circle from the large loop, but since the second crossover may not have occurred at exactly the same site as the first crossover, some bacterial genes may now be present in the smaller virus circle. Because bacteria have genes for properly metabolizing galactose-1-phosphate, we may now have a virus containing the gene for curing the galactosemia lesion. In that case, all we have to do is propagate these unusual viruses until we have many of those viral particles. They can then be introduced into human cells in a tissue culture so chosen that the only cells able to survive will be those that, in fact, have taken up viral particles containing the normal gene. In this way, galactosemic human cells in culture have actually been cured of their biochemical deficiency, benign viruses being used as the means of transferring genes between bacteria and human cells. Curing a galactosemic individual presents some additional technical problems, but these are certainly not insurmountable and will be conquered in time.

An extension of the above technique may lead to other genetically engineered cures, perhaps for diabetes (caused by deficient insulin production), gigantism and dwarfism (caused by aberrant pituitary function), sexual aberrations (caused by abnormal steroid hormone metabolism), and other genetic abnormalities.

There are dangers as well as possible benefits from this new technique. If genes for resistance to penicillin and streptomycin or genes for producing malignant tumors are introduced into bacterial viruses, there is always the risk that the new genetic combinations may give rise to pathogenic organisms insensitive to all known antibiotics or to cancerforming bacteria. In recognition of these dangers, a group of prominent scientists has recently called for a moratorium on genetic engineering experiments, at least until a proper series of guidelines can be worked out to control the probable accidents. But even if agreed to by all scientists, such a moratorium would be difficult to enforce, and an unscrupulous group might even use these techniques as a means of fabricating new weapons of war.

As always, advances in scientific knowledge open Pandora's box ever wider. Will humans be sufficiently intelligent and disciplined to handle the dangers? We will soon find out.

Columnist Arthur W. Galston teaches biology at Yale University.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon Daylight increases quite rapidly in duration during late February and early March as the sun, shifting its position northward with respect to the earth, rises earlier, sets later, and follows a progressively higher and longer path in its journey across the sky. The sun is still below the horizon for more than half the day, however, so that the cooling process continues in the Northern Hemisphere, although at a diminishing rate.

Evening moonlight will be with us through the last half of February. We should easily see the early crescent moon at mid-month; by the 19th it will have grown to first-quarter; by the 25th it will be full. Rising nearly an hour later after sundown each night, but remaining in the sky past sunrise, the moon will be waning to last-

quarter by March 4 and to new moon by March 12.

Stars and Planets There are so many bright stars in the southern and southwestern sky on the evenings of February and early March that it may be difficult to identify Saturn, the only planet on our star map this month. The planet is bright enough, but it has too much competition from the nearby stars of Orion, Auriga, Canis Minor, and Canis Major.

The other planets are below the horizon at the time for which the February map was prepared. Jupiter and Venus are evening stars, low in the southwest for a brief period before they set, although Jupiter will be setting too early to be seen by the end of February. Mercury and Mars are in the morning sky. Mars, rising after midnight, will be well up in the southeast at dawn, but not very bright. Mercury rises in morning twilight, but the dawn brightens too soon for us to see it.

February 17: Venus and Jupiter, in conjunction, make an interesting pair low in the southwest after sundown. Seldom will you see two bright planets so close together. Venus is the brighter of the two. They separate on successive nights, Venus becoming more prominent, Jupiter disappearing into the twilight.

February 20: Mercury resumes its direct (easterly) motion.

February 21-22: Saturn is the bright object to the left and below

the moon on the 21st; above the moon on the 22nd.

February 25: The moon is at perigee, nearest earth. This perigee occurs only three hours before the moon is full, so we can expect exceptionally strong tides in the next twenty-four hours. Perigee enhances the effect of spring tide, which occurs at each new and full moon.

March 6: Mercury is at its greatest distance to the right of the sun (westerly elongation). But this is not a favorable morning elon-

gation; the planet is still quite low as the sky brightens.

March 10: The crescent moon should help in finding Mars this morning. The planet is to the right of the moon, in the southeast at dawn. There are no bright stars nearby to compete with it.

March 11: The moon is at apogee, farthest from earth.

March 14: Saturn ends its retrograde (westerly) motion. It now begins to move easterly, taking it toward Pollux and Castor, the bright stars of Gemini.

★ Hold the star map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:15 p.m. on February 15; 9:25 p.m. on February 28; and 8:25 p.m. on March 15; but it can also be used for about an hour before and after these times.









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The Myth of Male Supremacy

Women of the Forest, by Yolanda Murphy and Robert F. Murphy. Columbia University Press, \$10.00 hard cover, \$3.45 paperback; 236 pp.

"We seem to have forgotten that the very essence of the relationship between the sexes is struggle, opposition, and socially useful, however unconscious, misunderstanding."

Women of the Forest

This work is an investigation into the relative positions of women and men and the dynamics of male-female interaction among the Mundurucú, a tropical forest people inhabiting the upper Tapajós region of central Brazil. The study, as its title indicates, focuses on Mundurucú women, but since sex roles are only understandable as complements of one another, this study of women is also an analysis (Freudian and otherwise) of men.

The book opens with an evocative description of a typical day in the life of a Mundurucu woman, followed by a historical overview of Mundurucú society up to the present time. Succeeding chapters discuss the social roles and life experiences of women and men in the context of both traditional institutions and recent acculturative changes. Throughout the book, the Murphys compare the position of women in Mundurucú society with that of women in contemporary America; their last chapter concentrates on what we can learn from bringing these apparently so divergent cases together.

The Mundurucu are particularly interesting from the perspective of sex-role studies because of the unusual degree to

which men and women live out their social lives apart from one another. Not only do men and women work separately, they also reside separately. The traditional village consists of family dwellings, which house groups of related females and their children, and a men's house in which all adolescent and adult men live. The women of a single household (and, to a lesser extent, women of separate households) form a closely cooperating social unit. They work together in the processing of manioc flour, the most arduous and time consuming of female tasks. Each village has a special shed where most of this work is carried out and which serves as a gathering place for women, a social counterpart to the men's house.

Hunting, the major male activity, is also commonly carried out in groups. The pursuit of game mobilizes the entire adult male population of a village and thus involves wider patterns of cooperation than are found among the women. The social world of men is, in general, broader than that of women since its scope extends beyond the village as well. A combination of matrilocality (postmarital residence in the wife's village) and patriliny (membership in descent groups based on kinship through males) moves men from one village to another and creates bonds of clanship among men of different local groups while women remain in place.

The distinction between the wider, public world of men and the more restricted, domestic world of women is similar to that found in our own society. The Mundurucú domestic world, however, is not the isolated nuclear

family. Moreover, women's household groups, although narrower in range than men's social groupings, appear to be more cohesive and enduring. In this connection, the Murphys remind us that if we consider women the captives of a closely knit domestic world, we might just as well consider men its outcasts.

How does the Mundurucú pattern of sexual separatism relate to their explicit ideology of male supremacy? This is the central question posed by the Murphys. They answer it by treating male superiority as a self-justifying ideology held primarily by the men and subscribed to only minimally by the women, a rationalization whereby men both exaggerate the extent of their power and reveal their deep-seated insecurities about it. As such, male supremacy functions less to reflect the social realities of male-female relationships than to cloak them in illusion.

This is best seen in the Mundurucú myth that accounts for the present hierarchical relationship between the sexes. This myth recounts how the sacred flutes-the central symbol of male power-which are kept hidden in a closed chamber of the men's house, were once owned by women. At that time, sex roles were the opposite of what they are now, and females were dominant. Men had to live in the family households and submit to the drudgery of manioc processing and the aggressive sexual advances of the women.

The phallic symbolism of this myth is not difficult to discern. Indeed, the men themselves draw the parallel between flute and penis as instruments for controlling the women. But the flute

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L. L. Bean, Inc. 619 Main Street, Freeport, Maine 04032 (like the penis?) can be lost. And the psychological experience of castration anxiety finds its social parallel in the fear of women taking over. As the Murphys point out, this myth of an age of female dominance is reminiscent of the similar projective fantasies of patriarchal European society, which reached their culmination in nineteenth-century theories of primitive matriarchy.

The foundations of male dominance in Mundurucú society are, according to the Murphys, particularly shaky because of social organizational features that accord significant strengths to women. In daily life, men exercise little real control over the activities of women. For a woman, marriage involves only minimal dependence on a particular man; her responsibilities are less to her husband than to the other women with whom she lives and works. Men and women confront each other not in pairs, but as collectivities, and the battle of the sexes is played out between two well-organized armies.

If either side has an advantage over the other, the Murphys claim it is the women. While men have their heads in the cultural clouds, women are "masters of the practical." They are not overly impressed with the trappings of male authority; although they are kept from looking upon the men's magic flutes, they have apparently succeeded in seeing through them. Women, as the Murphys see it, have the security that comes of their controlling role in the only inherently meaningful human activity-the creation of new life.

This familiar argument, which grants women an inside track on the course toward existential salvation at the same time it denies them a psychic life as complex as that of males, is one that I am reluctant to accept. I have similar reservations about the Murphys' tendency to view culture as an elaborate scheme devised by men to escape from their own basic insignificance. Do they really mean to reduce the cultural dimensions of human behavior to some kind of psychological defense mechanism? And would they want to have to defend the position that the world view of women is more "natural" and less culturally determined than that of men? I think not. These objections notwithstanding, the Murphys do well to have us think about possible universal dimensions of male and female experience.

Another important aspect of the Murphys' analysis of sex roles is a consideration of how they are affected by socioeconomic change. By the time of the Murphys' field work in the early 1950s, many Mundurucú had abandoned their traditional villages to participate full time in the extraction of rubber. This highly individualized economic activity has led to the breakdown of traditional patterns of intrasexual cooperation and increased the mutual dependence of husband and wife. In new Mundurucu settlements, the nuclear family is the basic social unit. These settlements have neither men's houses nor communal manioc-processing sheds.

Mundurucú women say they prefer this new way of life. They like having their husbands in the house and even get help from them in the tedious work of preparing manioc flour. changed situation may, however, have disadvantages that they do not as yet suspect. The disappearance of traditional forms of female cooperation has deprived them of an important source of solidarity as well as exclusive control over a crucial part of the productive process. Men, as rubber gatherers, take on a stronger role as economic providers and become women's only links to an outside world whose material goods they have come to require. Although the new relationship between the sexes "has the appearance of growing equality . . . the women may well discover that they have traded the symbolic domination of the men, as a group, over the women, as a group, for the very real domination of husband over wife."

Whether or not Mundurucú women are indeed better off than they were before, they think they are. They have played an active role in both the direction and rate of cultural change. Their desire for trade goods has pushed the men into increasing involve-

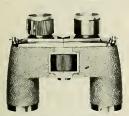


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ment in the local economy. Despite the greater control they may be able to exercise over their respective wives, the men-in their transition from independent tribesmen to rural wage laborers-have, in general, lost more than the women. As is commonly the case in acculturation, the continuity of women's activities in the domestic sphere provides their lives with focus and meaning, while men have been deprived of virtually all traditional bases of dignity and self-respect. While Mundurucu men speak nostalgically of days gone by, women view with relative indifference the passing of an order to which they had less reason to feel committed. In effect, Mundurucú women have conspired in the downfall of Mundurucu men. Can a more general moral be drawn from this story? Caveat viri-let the men beware!

Dealing with the relative status of the sexes in cross-cultural perspective is a difficult business. Should we base our analysis entirely on the participants' own view of their situation or should we also take into consideration phenomena such as false consciousness? And what are our methods? Do we invoke the powers of empiricism or do we claim that our human interpretive abilities transcend cultural boundaries?

It has been pointed out that theories in the natural sciences generally involve an increase in knowledge over our commonsense understandings, whereas theories in the social sciences too often involve just the reverse. We sacrifice the sophistication, richness, and density of our experience as social beings in an attempt to achieve objectivity. The Murphys have risked being charged with subjectivism or ethnocentrism by putting much of themselves into their study of the Mundurucú. In doing so, however, they have produced a particularly moving and thoughtprovoking analysis of sex roles and sex identity.

Judith Shapiro is an assistant professor of anthropology at the University of Chicago and has done field work among the Yanomamo and Tapirapé Indians of Brazil.



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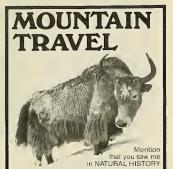
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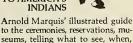
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of the Nuba [December, 1974] might have done well to limit his great admiration for Leni Riefenstahl's artistic sensitivity and ability to just that and avoided placing himself in the grossly contorted posture achieved by trying to justify or whitewash her conscious collaboration with the Nazi movement in Germany.

Many readers of Natural History probably never heard of Riefenstahl, and Beard served no good purpose with his sanitized references to her past. Anyone who has seen Triumph of the Will, a chilling piece of propaganda commissioned by Goebbels, knows that she relished every second of its production-to this day it is recognized as the prototype of effective, overt, and conscious political propaganda for evil. Beard's mushy attempt, to include her among that naïve group of apolitical artists who are "used" by the societies around them for furthering iniquitous goals, fails badly. Riefenstahl's hand lies as heavily on the millions of corpses (innocent concentration camp victims, noncombatant civilians, and soldiers, German and non-German) as do those of Hitler, Hess, and the other savages she photographed at Nuremberg, where the death warrants for those millions were figuratively signed. She was judged, not as Beard reports, for the clarity of her artistic vision and transcription of events; she was judged for her willing and aware participation in the events. No one can deny her physical beauty or her genius with a camera, any more than one can deny Hitler's spellbinding oratory-but neither can one ignore the use to which she put her talents.

I wish Riefenstahl no further ill. Her sufferings at the hands of a vengeful world may possibly have been adequate for her to appreciate the folly of evil in her youthful years. Eichmann had only that instant of eternity as his vetebrae separated on an Israeli scaffold; Riefenstahl will hopefully have many more years to live and reflect. Perhaps she can turn her genius toward more positive human values.

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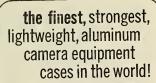
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Announcements

Puppets: Dance and Drama of the Orient continues in Gallery 77, located on the first floor of the Museum, through April 20. This stunning exhibit is a major guide to the centuries-old role of shadow theater and other forms of puppetry in traditional Oriental drama. Two- and three-dimensional puppets, as well as masks, musical instruments, costumes, scenery, and other theater paraphernalia of Indian and Chinese shadow figures are discussed and demonstrated on Wednesdays and Sundays, from 1:00 to 4:00 р.м.

In conjunction with the above exhibit, Chhau, the Masked Dance of Bengal—a ritualistic dancedrama based on themes from the Ramayana—will be shown in the Museum's Auditorium on Sunday, February 16, at 2:00 P.M. and at noon on Monday, February 17.

In the People Center a lecturedemonstration will be given on the "Masks of Bengal," illustrating the use of masks in rituals and dances of the annual Sun Festival of West Bengal. February 16 and 17, at 1:30 P.M.

Insects and Us, African Corridor, second floor, runs through early April. This exhibit explores the relationship between man and insects, the economic impact of insects, the role of insects in disease, and entomological research at the Museum.

Human Variation, Hall of the Biology of Man, first floor, depicts the myriad genetic and environmental influences that affect human populations. This new area is both an exhibit and a teaching

display, explaining the complexities of human diversity through film, photographs, cartoons, and simple diagrams.

In the Hayden Planetarium, "Sol," continuing through April 7, explores the relationship between life on earth and solar energy. Sky shows begin at 2:00 P.M. and 3:30 P.M. during the week, with more frequent showings on weekends. Admission is \$1.75 for adults, and \$1.00 for children.

On Tuesday, February 18, eightyfive voyagers will set off for a Tour of Peru, Tierra del Fuego, and Patagonia, under the guidance of Dr. Junius B. Bird, the Museum's distinguished curator emeritus and former curator of South American archeology. Stops will be made to investigate the rich bird life of Punta Arenas, the fauna of the Falklands, and at Navarino Island, Cape Horn, to explore the 600-footdeep Mylodon Cave. For detailed information contact Gregory Long at (212) 873-1300, ext. 546.

The Members Program will be held Thursday evenings at 8:00 P.M. in the Auditorium. On February 6, Arthur Wilson will present *The Greatness of Spain*, a documentary depicting the people, costumes, and economy of that country. On February 20, the Oxford zoologist Dr. John Paling will show *Frontiers of Wildlife Photography*, a revealing film on the private life and behavior of animal species.

On Saturday, February 15, at 11:00 A.M. in the Auditorium, A Very Special Clown introduces Salvatore Guida, renowned mime and dancer.

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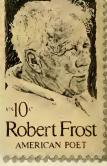
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Cover: In the secondary jungle of Sarawak, a tarsier clings to a tree with the soft, rounded pads on the tips of its elongated toes. This small primate is considered an intermediate form between prosimians and simians. Photograph by S. C. Bisserot. Story on page 52.



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Letters

Friends, Enemies . . . and the Whooping Crane

David Zimmerman's Natural History piece on whooping cranes [December, 1974] suffers from being misinformed and is quite unfair to Dr. Ray C. Erickson's pioneering work with these birds at the Patuxent Wildlife Research Center.

For example, the National Audubon Society does not hold that "the work of increasing the population must be left to the [wild] birds themselves." Audubon did object to the crane propagation program until it felt satisfied that the potentialities exceeded the risks, but then officially endorsed the program in Audubon magazine in 1967, and Dr. Erickson has not failed to take precautions against inbreeding in the captive flock. Detailed records have been kept of the parental nest location of each egg, and the birds are marked and pedigreed.

Much remains to be learned about these cranes, especially the art of restoring them to the wild, but the Patuxent program has made significant progress in surmounting obstacles as these were encountered.

ROLAND C. CLEMENT
Vice President
National Audubon Society
(This letter was cosigned by William G. Conway, Vice Chairman,
New York Zoological Society.)

Zimmerman is somewhat unfair in putting down the work of the Endangered Species Program when anything that is said in criticism of such work is likely to be used against it by those who still are only too ready to criticize. Many ghosts of the opposition of the 1950s are only too ready to say "I told you so" and to knock the Patuxent laboratories. This is even true within the Department of the Interior, where the power of budget allocations lies.

A number of complaints about

Patuxent, such as the lack of airconditioning equipment, are due to higher-ups, rather than to Dr. Erickson. The program has always been a stepchild within the bureau. The supporting budget has never been adequate. Additionally, a strong element among the public and some of the conservation societies are still dedicated to letting nature take its course, and to letting nature's noblemen, like the whooping crane, fly off into the sunset on their own, without any tampering by the hand of man (except of course for man having created the conditions that push the species into oblivion).

Cranes, once brought up in captivity, tend to lose their migratory instinct. It should be possible to reinstitute the Mississippi drainage basin population of whooping cranes (of which "Josephine" was the last survivor) on some federal lands, letting them gradually fly free, isolated from the remnant migratory population. A population of sandhill cranes in that part of the country is only a wanderer, not at all such a reckless migrant as the remaining wild whooping cranes. Proper management could develop a sedentary flock in ample, protected spaces within parts of the original range of the whooping cranes. This could be an option for the Patuxent population.

S. DILLON RIPLEY
President, International
Council for Bird Preservation;
Secretary, Smithsonian Institution

A far more appropriate title would have been "The Patuxent Wildlife Research Center: Boon or Boondoggle." As Zimmerman rightly stresses, the top priority of all efforts to save the whooping cranes, or any other endangered species, should be inducing the remaining specimens to reproduce. The present program has continually failed at this.

If but a single pair of whooping cranes remained, I would

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prefer to have that pair entrusted to the skilled care of a dedicated aviculturist who has demonstrated his ability to propagate related species under captive conditions, than to have them placed at the disposal of a half-hearted, understaffed, underfinanced bureaucratic scheme in which they would more than likely be strangled in red tape.

Serious consideration should be given to "farming out" the birds now in residence at Patuxent to zoos or private bird propagators. I fear, however, that this proposal will never be weighed on its merits; that the present guardians of the whooping crane will be unwilling to admit that others might be capable of achieving a breakthrough where they have failedpetty bureaucrats whose concern for their own image overrides their concern for whooping

My thanks to Natural History for bringing public attention to the plight of the whooping crane, and my congratulations to the author for a well-written, thought-provoking, and much needed article on a topic of great controversy.

> DAVID L. BENDER Editor Avicultural World

The article on the whooping crane management program of the Patuxent Wildlife Research Center presented a clear historical account of the accomplishments and failures of the captive breeding program to date, although it was perhaps overcritical of Dr. Erickson, I believe Erickson has done a creditable job, given the inherent difficulties of managing cranes in captivity, the political sensitivity of the issue, and the severe budget ceiling. Perhaps the policy of the budgeting division of the bureaucracy should be more heavily criticized than Dr. Erickson.

Prior to 1973, the Patuxent program employed three scientists-a physiologist, a nutritionist, and a veterinarian-who were instrumental in devising excellent captive maintenance techniques for whooping cranes. However, once one masters the maintenance of cranes in captivity,

Continued on page 74



British Columbia, Canada.

These pictures are just a sample of what is waiting for you in British Columbia. 1. One of many intriguing shops that can be found throughout the Province. 2. Long Beach on Vancouver Island, 11 miles of unbroken beach on the Pacific Ocean. 3. The Williams Lake Stampede. Dozens of rodeos take place all summer long in British Columbia's cattle country. 4. An outdoor restaurant in Gastown, the original settlement of British Columbia's largest city, Vancouver. For more pictures and lots more information write: British Columbia Department of Travel Industry, 1019 Wharf Street, Victoria, British Columbia V8W 2Z2. Or see your local travel agent.







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Kalliope and the Kaa'ba: The Origin of Meteorites

One of the seven wonders of the ancient world was the Temple of Diana at Ephesus, in Asia Minor, an exquisite example of Greek monumental architecture. The Holy of Holies in this temple was a great black rock, probably metallic, that had fallen from the skies, a sign from the gods, perhaps an arrowhead shot from the crescent moon, the symbol of Diana the Huntress.

Not many centuries later-or possibly at the same time-another great black metallic rock fell out of the sky, onto the Arabian Peninsula. There, in pre-Muslim times, it was enshrined in a Meccan temple and offered something akin to worship. Then, in the seventh and eighth centuries A.D., came the stunning success of the Muslim religion, founded by Muhammad, who lived out most of his days not far from this large dark stone. The earlier worship of the stone was incorporated into Islam, and today a principal focus of every pilgrimage to Mecca is that same stone-the Black Stone of the Kaa'ba. (Many other religions have shamelessly co-opted their predecessors. Consider, for example, the Christian festival of Easter, in which the ancient fertility rites of the spring equinox are today cunningly disguised as chickies, eggies, and bunnies. Indeed, the very name Easter is a corruption of the name of the great Near Eastern earth mother goddess, Astarte. The Diana of Ephesus is a later and Hellenized version of Astarte and Cybele.) While Muslim traditionalists hold that the Black Stone is supernatural, and two geologists have recently suggested it is an agate, the usual explanation of its origin is as a meteorite.

In primitive times, a great boulder falling out of a clear blue sky must have provided on-lookers with a memorable experience. But the black stones had a greater importance: At the dawn of metallurgy, iron from the skies was, in many parts of the world, the purest available form of this metal. The military significance of iron swords and the argicultural significance of iron plowshares made metal from the sky a concern of practical men.

Rocks still fall from the skies; farmers still occasionally break their plows on them; museums still pay a bounty for them; and, very rarely, one falls through the eaves of a house, narrowly missing a family in its evening hypnagogic ritual before the television set. We call these objects meteorites. But naming them is not the same as understanding them. Where, in fact, do meteorites come from?

Between the orbits of Mars and Jupiter are thousands of irregularly shaped, tumbling little worlds called asteroids. Ceres, the first asteroid to be found, was discovered telescopically on December 31, 1800, by Giuseppe Piazzi, an Italian monk. Ceres, 620 miles in diameter, is by far the largest asteroid. Since the finding of Ceres, almost 2,000 more asteroids have been discovered and named.

Asteroids are given a number indicating their order of discovery. Following Piazzi's lead, a great effort was also made to give the asteroids names-female names, preferably from Greek mythology. But 2,000 asteroids is a great many, and the nomenclature becomes a little ragged toward the end. We find 1 Ceres, 2 Pallas, 3 Juno, 4 Vesta, 16 Psyche, 22 Kalliope, 34 Circe, 55 Pandora, 80 Sappho, 232 Russia, 324 Bamberga, 433 Eros, 710 Gertrud, 747 Winchester, 904 Rockefelleria, 916 America, 1121 Natasha, 1224 Fantasia, 1279 Uganda, 1556 Icarus, 1620 Geographos, 1685 Toro, and 1694 Ekard (Drake [University] spelled

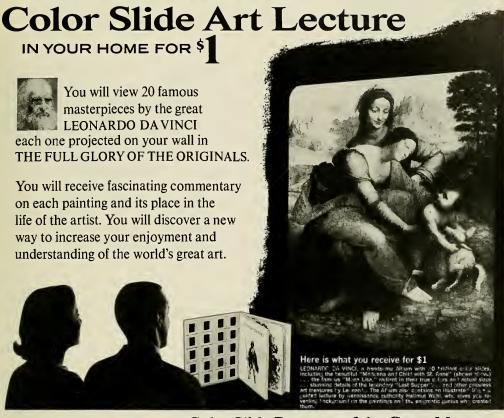
backwards)—1984 Orwell is still available. There is no question that wives, girl friends, real and hoped-for patrons, jingoist sentiments, and plain free association have played a role in the naming of the asteroids.

Many asteroids have highly elliptical, or stretched-out, orbits, not at all like the almost perfectly circular orbits of Earth or Venus. Some asteroids have their far points from the sun close to the orbit of Mercury; some, like 1685 Toro, live out their days between the orbits of Earth and Venus. Since there are very many asteroids on very elliptical orbits, collisions among them are inevitable over the lifetime of the solar system. Most collisions will be of the overtaking variety; one asteroid nudging up to another, making a soft, splintering crash. Since the asteroids are so small, their gravities are low and the collision fragments will be splayed out into space into slightly different orbits those of the parent asteroids. It can be calculated that such collisions will occasionally produce fragments that, by accident, intercept the earth, fall through its atmosphere, survive the ablation of entry, and land at the feet of a quite properly astonished itinerant tribesman.

The very few meteorites that have been tracked as they enter Earth's atmosphere originated back in the main asteroid belt, between Mars and Jupiter. Laboratory studies of the physical properties of some meteorites also show them to have originated where the temperatures are those of the main asteroid belt. The evidence is clear: the meteorites ensconced in our museums are fragments of asteroids. We have on our shelves pieces of cosmic objects!

But which meteorites come from which asteroids? Until the last few years, answering this question was beyond the powers of planetary scientists. But recently it has become possible to perform spectrophotometry of asteroids in visible and near infrared radiation; to examine the

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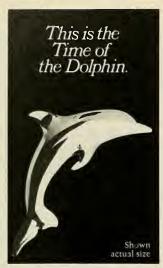
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polarization of sunlight reflected off asteroids as the geometry of the asteroid, the sun, and the earth changes; and to examine the middle infrared emission of the asteroids. These asteroid observations, and comparable studies of meteorites and other minerals in the laboratory, have provided the first fascinating hints on the correlation between specific asteroids and specific meteorites. More than 90 percent of the asteroids studied fall into one of two composition groups: stony-iron or carbonaceous. Only a few percent of the meteorites on earth are carbonaceous, but carbonaceous meteorites are very friable and rapidly weather to powder under typical terrestrial conditions. They probably also fragment more readily upon entry into the earth's atmosphere. Since stony-iron meteorites are much hardier, they are disproportionately represented in our museum collections of meteorites. Carbonaceous meteorites are rich in organic compounds, including amino acids-the building blocks of proteins-and may be representative of the materials from which the solar system formed some five billion years ago.

Among the asteroids that appear to be carbonaceous are 1 Ceres, 2 Pallas, 19 Fortuna, 324 Bamberga, and 654 Zelinda. If asteroids that are carbonaceous on their outsides are also carbonaceous on their insides, then most of the asteroidal material is carbonaceous.

Typical asteroids showing properties of stony-iron meteorites are 3 Juno, 8 Flora, 12 Victoria, 89 Julia, and 433 Eros. Several asteroids fit into some other category: 4 Vesta resembles a kind of meteorite called a basaltic achondrite, while 16 Psyche and 22 Kalliope appear to be largely iron.

The iron asteroids are interesting because geophysicists believe that the parent body of an object greatly enriched in iron must have been molten in order to separate out the iron from the silicates. On the other hand, for the organic molecules in carbonaceous meteorites to have survived at all they must never have been raised to temperatures hot enough to melt rock or iron. Thus, different histories are implied for the different asteroids.

From the comparison of asteroidal and meteoritic properties, from laboratory studies of meteorites, and from computer projections back in time of asteroidal motions, it may one day be possible to reconstruct asteroid histories. Today, we do not even know whether asteroids represent a planet that was prevented from forming because of the powerful gravitational perturbations of nearby Jupiter or whether they are the remnants of a fully formed planet that somehow exploded. Most students of the subject incline to the former hypothesis because no one can figure out how to blow up a planetwhich is just as well. Eventually we may be able to piece together the whole story.

There may also be in hand meteorites that do not come from asteroids. Perhaps there are fragments of the moons of Mars or of the surface of Mercury or of the satellites of Jupiter sitting dusty and ignored in some obscure museum. Some carbonaceous meteorites are probably pieces of comets. But the true picture of the origin of the mete-

orites is beginning to emerge.

The Holy of Holies in the Temple of Diana at Ephesus has been destroyed. But the Kaa'ba stone has been carefully preserved. It would be of great interest to examine, with the full armory of modern laboratory techniques, a small fragment of the Kaa'ba stone. Its composition could be determined with precision and its supposed meteoritic origin tested. Its cosmic ray exposure age-the time spent from fragmentation to arrival on the earth-could be established. And it would be possible to test hypotheses of origin, such as, for example, the idea that some 50 million years ago, before the origin of the primates, the Kaa'ba stone was chipped off an asteroid named 22 Kalliope, orbited the sun for ages of geologic time, and then accidentally encountered the Arabian Peninsula 2,500 years ago.

Carl Sagan is director of the Laboratory for Planetary Studies and professor of astronomy at Cornell University.

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In Search of the Antiaging Cocktail

Some cells nurtured in an artificial medium seem to have achieved immortality

Life has been called a fatal disease. For all but a few organisms, death is an inevitable consequence of existence. From a biological point of view, this makes good sense, for death removes existing organisms and recycles their components, thus providing both environmental niches and basic chemicals for new life. The few exceptions to this almost universal rule include both the smallest and largest of living things.

Bacteria and similar microorganisms seem able to live indefinitely, granted only the availability of food and the removal of waste products. When cultured in this manner, such organisms reproduce by cell division at a constant rate that seems unaffected by the passage of time. One has to conclude that under appropriate conditions, these minuscule forms of life are at least potentially immortal. The only sense in which death occurs is that the "mother" cell disappears in the process of giving rise to the two "daughter" cells. Among the larger forms of life, individual giant redwoods and bristlecone pines seem able to go on living and growing for thousands of years. Possibly they could live forever or at least until disease or some accident, such as lightning or fire, puts an end to their lives.

For most species of animals, there seems to be a built-in timer that dictates the maximum life-span. For humans, the average life-span may be approximately the biblical three score and ten years, although one Quebec man is recorded as having lived to 113. (Stories of 160-year-old resi-

dents of the Caucasus and Azerbaijan must be treated skeptically because of the unavailability of birth certificates or other proof of date of birth.) Dogs generally die at the age of ten to twelve years, although several have lived beyond thirty, horses live from forty to fifty years, elephants live an average of seventy years, while houseflies last about seventy days.

As is widely known, advances in medicine have resulted in an increase in the average human length of life, but this is not due to an increase in the upper limit of the life-span. What preventive medicine and public health measures have done is reduce the number of early deaths from accidents and diseases associated with maternity, infancy, and childhood. As a result, the population profile, which used to look like a squat pyramid-with a large population base at birth and a sharp apex at the age of death-now looks more like a column of uniform width from birth until relatively old age, at which time there is a gentle taper to a point. Given contemporary medical advances, there is now no correlation between age and death rate below the age of thirty; beyond that point, the probability of death doubles with each eight years of increasing age. This is generally taken as meaning that the degenerative processes leading to death set in at about the age of thirty.

Within any given species, there is some variation in average life-span, and sometimes these variations can be traced to definite causes. The most obvious cause is the genetic background of the individual. Several decades ago, the American biologist and biometrician Raymond Pearl showed a positive correlation between the age of an individual at death and

the age of that person's parents at death. Pearl found that 45.8 percent of those who lived beyond age seventy had parents who did likewise, while only 13.4 percent of the septuagenarians had two short-lived parents. These figures seem to indicate that the best way to live to a ripe old age is to receive genes for longevity. And an obvious inference is that selective breeding among extraordinarily long-lived individuals might lead to an extension of the normal life-span. Unfortunately, children cannot choose their parents nor can individuals who wish to become parents sense the ultimate age of their mates.

Direct experimental proof of the connection between genetics and age at death has been demonstrated by several researchers. Working with rotifers-a form of protozoan-Albert Lansing, a specialist in the physiology of aging at the University of Pittsburgh School of Medicine, was able to modify the creatures' normal lifespan of twenty-four days by simple selection. Eggs taken only from adolescent rotifers were grown, and the process was continued for more than fifty generations. The average life-span of the resultant individuals was found to have increased to more than one hundred days. Contrariwise, repeated selection of eggs from senescent rotifers for more than fifty generations decreased the life-span to fourteen days. The generalization seems clear: young mothers give birth to longer-lived offspring; older mothers to shorter-lived offspring.

Robert Sokal, a statistical biologist at the State University of New York at Stony Brook, achieved the same result as Lansing but in a different way. Working with flour beetles, he

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killed all beetle mothers shortly after they had produced their first eggs. Within forty generations he succeeded in decreasing the average life-span of the resultant population. Sokal reasoned that this change occurred because all those beetle mothers with potentially longer life-spans had had their lives cut short, while those with potentially short lifespans lived to their full life expectancy. The result, in a kind of test-tube evolution study, was a drift of the population toward shorter life-spans.

In some species, including the human, there is a correlation between gender and longevity. Thus, in our society, women live an average of more than five years longer than men. Nobody yet knows whether this is due to the genetic difference between males and females (females have twenty-two pairs of autosomal chromosomes plus a pair of X chromosomes; males have the same number of autosomal chromosomes but substitute one longer Y chromosome for one of the X chromosomes) or whether the earlier death of men is related to a difference in their life styles. Whatever the cause, this differential mortality results in a marked excess of females in the

older population.

Other factors affecting life-span in various species are the temperature at which young are reared (particularly in animals whose body temperature is not stable), diet (especially in early development), and exposure to radiation. Fruit flies, accordingly, live ten times longer at a temperature of 10° C. than at 30° C.; rats given a barely adequate caloric diet live longer than their well-fed siblings; and the lifespan of mice exposed to whole body irradiation decreases progressively as the radiatioh dose increases. These experimental data have led certain experimenters to reason that aging is caused by some product whose concentration in the body is increased by high levels of nutrition, high rates of metabolism, and high doses of radiation. It has also led to attempts to ameliorate the harmful effects of these factors by dietary means, which might act as a kind of fountain of youth. For example, radiation is known to cause the formation of free radicals, or molecules with unpaired electrons. Such molecules are extraordinarily reactive, and the harmful effect of radiation may result from the modification of nucleic acid and other important molecules by radiationinduced free radicals. One way to get around this trouble is to feed the body compounds that are known as "reducing agents," or antioxidants. The theory is that such ingested substances will react directly with the free radicals, thus keeping them from affecting important molecules in the cell. Vitamin E, a known antioxidant, has shown some promise in this regard.

One of the paradoxes of the aging process is its alteration when cells are removed from their natural positions in the body and are grown in artificial chemical media. The famous chicken heart culture experiments of Nobel laureate Alexis Carrel, in which Charles Lindbergh collaborated, showed that tissue from that organ could be artificially kept alive for more than thirty years-many times the normal life-span of the chicken from which it came. In fact, that heart tissue might still be alive today if a careless technician had not inadvertently terminated the ex-

periment.

Intimations of immortality are also gleaned from experiments with plant tissue cultures. As I have mentioned in several previous columns, cells removed from a carrot root in 1937 and put in an artificial medium are still dividing and show no sign of running down. In nature, by contrast, a carrot lives a maximum of two years.

Human cells also show evidence of extraordinary longevity when removed from the body. Helen Lane, a woman with cancer of the cervix, provided cells for tissue culture in 1951. The donor has since died, but her cells, the noted HeLa strain used in laboratories all over the world, continue to grow. For such cells, it may be said that mortality is a consequence of being included in a differentiated body. In a sense, experimental immortality is at hand for everyone-simply by donating some skin cells to a tissue culture laboratory, your cells, containing your genes, can be replicated possibly forever.

A different pattern is shown by human fibroblasts-the cells that form the connective tissues of the body. Microbiologist Leonard Hayflick, of Stanford University School of Medicine, showed that fibroblast cultures were limited to about fifty divisions, accomplished over a period of about eight months. If the cultures were transferred to cold conditions in the middle of the experiment, thereby stopping cell divisions, the cultures would "remember" the number of divisions remaining before they ceased activity. In a companion study, Hayflick showed that the older the individual used as the source of the fibroblasts, the fewer the resulting divisions in culture. These data provided strong support for the "hourglass" theory of aging, in which the buildup of some harmful metabolite (or depletion of some essential substance) is envisaged as the cause of the aging process.

This research was recently shaken by the discovery by biochemist Lester Packer, and his colleagues in the department of physiology and anatomy at the University of California at Berkeley, that the inclusion of vitamin E in the culture medium extends the ability of fibroblasts to divide. In fact, vitamin E may even change cultured fibroblasts into indefinitely prolonged cultures, like those of HeLa cells and plant tissues. Whether this effect of vitamin E is due to its antioxidant properties or to some other

action is not yet known.

In the human body, which contains nondividing as well as dividing cells, the phenomenon of aging is not likely to be attributable to a single cause. Nerve cells, for example, never divide after their formation. As life progresses, they suffer continual wear and tear until they die. At maturity, the brain has about one billion nerve cells. It is estimated that each day thereafter about 10,000 of them die and are irretrievably lost, never to be replaced. By the age of sixty-five, about 20 percent of all brain neurons are gone; this may account for the diminished mental acuity of some elderly people.

Muscle is another nondividing kind of cell in which wear and tear may be expected to play an important role. Much interest has recently been shown in collagen, the noncellular matrix that binds many cells together, forms the basis for connective tissue, and is the milieu in which bone calcification occurs. The collagen molecules in young persons are highly hydrated and quite flexible; the tissues of the young are accordingly supple. In advancing age, collagen becomes much more highly cross-linked and rigid, possibly as a result of oxidative changes. The resultant rigidity reduces the efficiency of muscles and such organs as the heart and lungs. Since collagen fibers cannot be renewed once they are laid down in the body, the loss of pliability leads to irreversible changes that are part of the total aging process.

But even tissues that can be renewed by cell division show diminished efficiency with increasing age. This may be related to an accumulation of perpetuated "mistakes" in the genetic apparatus. These could be in the form of extra chromosomes or errors at the level of DNA replication that cause mutations. As the load of accumulated errors becomes greater and greater, the rate of replacement of worn-out cells that need renewal (red blood cells, for example) diminishes progressively, and recovery from any injury becomes more diffi-cult. Like the "wonderful onehoss shay/that was built in such a logical way/it ran for a hundred years to a day" and then suffered total collapse (Oliver Wendell Holmes, The Deacon's Masterpiece), the body keeps functioning, all the parts suffering progressive attrition until some breakdown becomes the ultimate insult that terminates life. It is not likely that any single elixir will be able to retard all these degenerative changes. At the very least, the fountain of youth will have to be a complicated, multicomponent, antiaging cocktail.

Columnist Arthur W. Galston teaches biology at Yale University.



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Velikovsky in Collision

When Earth in Upheaval collides with the theory of continental drift, one of the most controversial figures in modern science goes down gloriously

Not long ago, Venus emerged from Jupiter, like Athena from the brow of Zeus-literally! It then assumed the form and orbit of a comet. In 1500 B.C., at the time of the Jewish exodus from Egypt, the earth passed twice through Venus's tail, bringing both blessings and chaos: manna from heaven (or rather from hydrocarbons of a cometary tail) and the bloody rivers of the Mosaic plagues (iron from the same tail). Continuing its erratic course, Venus collided with (or nearly brushed) Mars, lost its tail, and hurtled to its present orbit. Mars then left its regular position and almost collided with the earth in about 700 B.C. So great were the terrors of these times, and so ardent our collective desire to forget them, that they have been erased from our conscious minds. Yet they lurk in our inherited and unconscious memory, causing fear, neurosis, aggression, and such social manifestations as war.

This may sound like the script of a very poor, late-late movie on TV; nonetheless, it represents the serious theory of Immanuel Velikovsky's Worlds in Collision. And Velikovsky is neither crank

nor charlatan—although to state my opinion and to quote one of my colleagues, he is at least glo-

riously wrong.

Worlds in Collision, published twenty-five years ago, continues to engender intense debate. It also has spawned a series of issues peripheral to the purely scientific arguments. Velikovsky was surely ill treated by certain academics who sought to suppress the publication of his work. But a man does not attain the status of Galileo merely because he is persecuted; he must also be right. The scientific and sociological issues are separate. And then, times and the treatment of heretics have changed. Bruno was burned to death, and Galileo, after viewing the instruments of torture, languished under house arrest. Velikovsky won both publicity and royalties. Torquémada was evil; Velikovsky's academic enemies, merely foolish.

As startling as his specific claims may be, I am more interested in Velikovsky's unorthodox method of inquiry and physical theory. He begins with the working hypothesis that all stories reported as direct observation in the ancient chronicles are strictly true—if the Bible reports that the sun stood still, then it did (as the tug of Venus briefly halted the earth's rotation). He then attempts to find some physical explanation, however bizarre, that would render all these stories both mutually consistent and true. Most scientists would do exactly the opposite in using the limits of physical possibility to judge which of the ancient legends might be literally accurate. (1 will devote a future column to the last important scientific work that used Velikovsky's method-Thomas Burnet's Sacred Theory of the Earth, first published in the 1680s.) Secondly, Velikovsky is well aware that the laws of Newton's universe, where forces of gravitation rule the motion of large objects, will not allow planets to wander. Thus, he proposes a fundamentally new physics of electromagnetic forces for large bodies. In short, Velikovsky would rebuild the science of celestial mechanics to save the literal accuracy of ancient legends.

Having devised a cataclysmic theory of human history, Velikovsky then sought to generalize his physics by extending it throughout geologic time. In 1955 he published Earth in Upheaval, his geologic treatise. With Newton and modern physics already under siege, he now took on Charles Lyell and modern geology. He reasoned that if wandering planets had visited us twice within a mere 3,500 years, then the history of the earth should be marked by its catastrophes, not by the slow and gradual change that Lyell's uniformitarianism requires.

Velikovsky scoured the geologic literature of the past hundred years for records of cataclysmic events—floods, earthquakes, volcanoes, mountain building, mass



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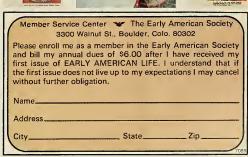
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extinctions, and shifts of climate. Finding these aplenty, he sought a common cause:

Sudden the agent must have been and violent; recurrent it must have been, but at highly erratic intervals; and it must have been of titanic power.

Not surprisingly, he invoked the electromagnetic forces of celestial bodies external to the earth. In particular, he argues that these forces rapidly perturb the earth's rotation—literally turning the earth over in extreme cases and exchanging poles for equators. Velikovsky offers a rather colorful account of the effects of such a sudden shift in the earth's axis of rotation:

At that moment an earthquake would make the globe shudder. Air and water would continue to move through inertia; hurricanes would sweep the earth and the seas would rush over continents. . . . Heat would be developed, rocks would melt, volcanoes would erupt, lava would flow from fissures in the ruptured ground and cover vast areas. Mountains would spring up from the plains.

If the testimony of human narrators provided the evidence for Worlds in Collision, then the geologic record itself must suffice for Earth in Upheaval. Velikovsky's entire argument hinges on his reading of geologic literature. This, I feel, he does rather badly and carelessly. I will focus upon the general faults of his procedure, not the refutation of specific claims.

First, the assumption that similarity of form reflects simultaneity of occurrence: Velikovsky discusses the fossil fishes of the Old Red Sandstone, a Devonian formation in England (350-400 million years old). He cites evidence of violent death-contortion of the body, lack of predation, even signs of "surprise and terror" engraved forever on fossil faces. He infers that some sudden catastrophe must have extirpated all these fishes; yet, however unpleasant the death of any individual, these fishes are distributed through hundreds of feet of sediments that record several million years of deposition! Likewise, the craters of the moon are similar in appearance, and each one formed by the sudden impact of a meteorite. Yet this influx spans billions of years, and Velikovsky's favored hypothesis of simultaneous origin by bubbling on the surface of a molten moon has been conclusively disproved by the Apollo landings.

Second, the assumption that events are sudden because their effects are large: Velikovsky writes graphically about the hundreds of feet of ocean water that were evaporated to form the great Pleistocene ice sheets. He can envisage the process only as a result of oceanic boiling followed by a general refrigeration:

An unusual sequence of events was necessary: the oceans must have steamed and the vaporized water must have fallen as snow in latitudes of temperate climates. This sequence of heat and cold must have taken place in quick succession.

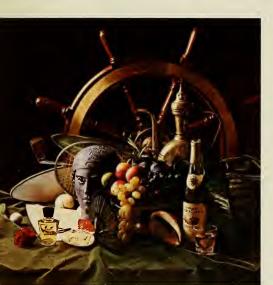
Yet glaciers are not built overnight. They formed "rapidly" by geologic standards, but the few thousand years of their growth allowed ample time for the gradual accumulation of snow by new precipitation supplied each year. One need not make the oceans steam; it still snows in northern Canada.

Third, the inference of worldwide events from local catastrophes: No geologist has ever denied that local catastrophes occur by flooding, earthquake, or volcanic eruption. But these events have nothing to do, one way or the other, with Velikovsky's notion of global catastrophe caused by sudden shifts in the earth's axis. Nevertheless, most of Velikovsky's "examples" are just such local events combined with an unwarranted extrapolation to global impact. He writes, for example, of the Agate Springs Quarry of Nebraska-a local mammalian "graveyard" containing the bones (according to one estimate) of nearly 20,000 large animals. But, this large aggregation may not record a catastrophic event at all-rivers and oceans can gradually accumulate vast quantities of bone and shell (I have walked on beaches composed entirely of large shells and coral rubble). Also, even if a local flood drowned these animals, we have no evidence that their contemporary brethren on other continents were the least bit bothered.

Fourth, the exclusive use of outdated sources: Before 1850, most geologists invoked general catastrophes as the major agent of geologic change. These men were not stupid, and they argued their position with some cogency. If we read only their works, their conclusions seem to follow. Velikovsky's entire discussion of the catastrophic death of European fossil fishes cites only the works of Hugh Miller in 1841 and of William Buckland in 1820 and 1837. Surely the past hundred years, with its voluminous literature, contains something worth noting. Likewise, Velikovsky relies on John Tyndall's work of 1883 for his meteorological notions about the origin of ice ages. Yet this subject has been actively discussed in geology during this century.

Fifth, carelessness, inaccuracy, and sleight of hand: Earth in Upheaval is studded with minor errors and half-truths, unimportant in themselves, but reflecting either a cavalier attitude toward the geologic literature or, more simply, a failure to understand it. Thus, Velikovsky attacks the uniformitarian postulate that present causes can explain the past by arguing that no fossils are forming today. Anyone who has dug old bones from lake beds or shells from beaches knows that this claim is simply absurd. Likewise, Velikovsky refutes Darwinian gradualism with an argument "that some organisms, like foraminifera, survived all geological ages without participating in evolution." This claim was occasionally made in literature more than fifty years old and written before anyone had seriously studied these single-celled creatures. But no one has maintained it since J.A. Cushman's voluminous descriptive work of the 1920s. Finally, we learn that igneous rocks-granite and basalt-"have embedded in them numberless living organisms." This is news to

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me and to the whole profession

of paleontology. But all these criticisms pale to insignificance before the most conclusive refutation of Velikovsky's examples-their explanation as consequences of continental drift and plate tectonics. And here Velikovsky is not to blame at all. He has merely fallen victim-as have so many others with the most orthodox among previously cherished opinions-to this great revolution in geologic thought. In Earth in Upheaval, Velikovsky quite reasonably rejected continental drift as an alternate explanation for the most important phenomena supporting his catastrophic theory. And he rejected it for the reason then most commonly cited among geologists-the lack of a mechanism to move the continents. That mechanism has now been provided with the verification of sea-floor spreading. The African rift is not a crack formed when the earth turned over rapidly; it is a part of the earth's rift system, a junction between two crustal plates. The Himalayas did not rise when the earth shifted but when the Indian plate slowly pushed into Asia. The Pacific volcanoes, the "ring of fire," are not the result of melting during the last axial displacement; they mark the boundary between two plates. There are fossil corals in polar regions, coal in Antarctica, and evidence of Permian glaciation in tropical South America. But the earth need not turn over to explain all this; the continents have only to drift from different climatic realms into their present positions.

Ironically, Velikovsky has lost more to plate tectonics than his mechanism of axial shifting for he has probably lost the entire rationale for his catastrophist position. As Walter Sullivan argues in his recent book on continental drift, the theory of plate tectonics has provided a stunning confirmation of uniformitarian preferences for ascribing past events to present causes acting without great deviation from their current intensity. For the plates are actively moving today, carrying their continents with them. And the sweeping panorama of attendant events-the worldwide belt of earthquakes and volcanoes, the collision of continents, the mass extinctions of faunas (see my column of October, 1974)—can be explained by the continuous movement of these giant plates at rates of only a few centimeters a year.

The Velikovsky affair raises what is perhaps the most disturbing question about the public impact of science. How is a layman to judge rival claims of supposed experts? Any man with a gift for words can spin a persuasive argument about any subject not in the domain of a reader's personal expertise. Even von Daniken sounds good if you just read Chariots of the Gods. I am in no position to judge the historical argument of Worlds in Collision. I know little of celestial mechanics and even less about the history of the Egyptian Middle Kingdom (although I have heard experts howl about Velikovsky's unorthodox chronology). I do not wish to assume that the nonprofessional must be wrong. Yet when I see how poorly Velikovsky uses the data I am familiar with, then I must entertain doubts about his handling of material unfamiliar to me. But what is a person who knows neither astronomy, Egyptology, nor geology to do-especially when faced with a hypothesis so intrinsically exciting and a tendency, shared, I suspect, by all of us, to root for the underdog?

We know that many fundamental beliefs of modern science arose as heretical speculations advanced by nonprofessionals. Yet history provides a biased filter for our judgment. We sing praises to the unorthodox hero, but for each successful heretic, there are a hundred forgotten men who challenged prevailing notions and lost. Who among you has ever heard of Eimer, Cuénot, Trueman, or Lang-the primary supporters of orthogenesis (directed evolution) against the Darwinian tide? Still, I will continue to root for heresy preached by the nonprofessional. Unfortunately, I don't think that Velikovsky will be among the victors in this hardest of all games to win.

Stephen Jay Gould teaches geology at Harvard University.

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The Persistent Guajiro

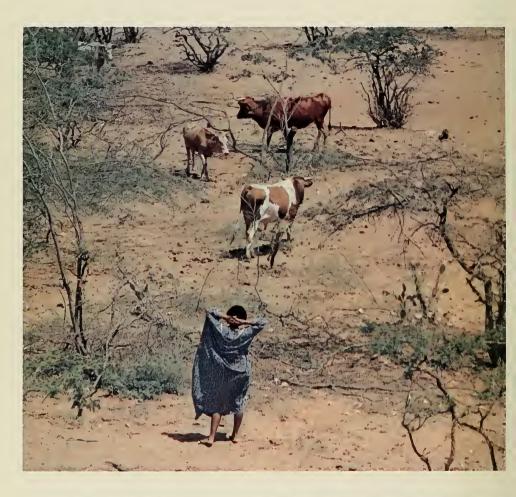
by Homer Aschmann

Four centuries after their land was conquered, a resilient Indian people continues to thrive on a harsh South American peninsula

The cultural encounter between American Indians and Western Europeans, which began in 1492, generally proved disastrous for the Indians. In some cases—the West Indies, the Argentine Pampa, and the eastern United States, for example—the Indians and their cultures were virtually eliminated, leaving behind only place names and names for a few objects. Elsewhere—Mexico and Chile, for instance—the Indians survived biologically, at least in their mestizo descendants, but their cultures and languages have become more and more Europeanized. Only in Guatemala and Bolivia do Indian ways of living and thinking still figure significantly in the national life, and even there the Indian fraction of the population grows smaller annually.

photographs by Victor Englebert





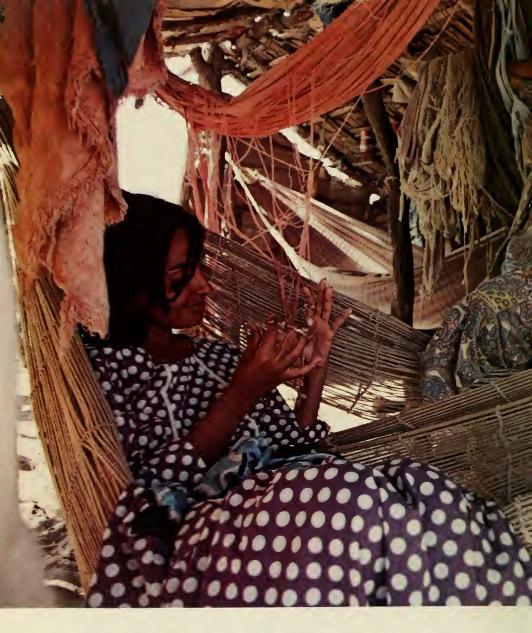
In a few cases, however, an Indian population has not only survived the shock of an invading culture, but has actually modified itself and begun to flourish. The population, often originally a small tribe, has grown in number, retained its native language, and maintained a distinctive value system. This vigorous survival is probably paid for in loss of material prosperity, but the carriers of these cultures are willing to bear that cost.

In the United States, the Navajo constitute the most vital such group. They are far more numerous than they ever were in the past and occupy, more or less exclusively, far more land. The Guajira Peninsula, the most northerly tip of South America, is occupied by another vital people—the Guajiro Indians—who show little sign of being comfortably assimilated into the national populations of Colombia and Venezuela, the countries that

Livestock are the mainstay of the Guajiro, and girls as well as boys learn to care for animals. Handdug pits, top right, provide much of the water in the arid peninsula. Brought up in cans, the water is poured into ollas (clay jugs), which are covered with net to facilitate carrying. Young boys, right, clean fish along the shore. Marine resources are accessible, but fishing has little prestige.







Using imported cordage, women weave chinchorros, openwork hammocks that are comfortable on the frequent hot nights.

control the lands where the Guajiro reside. Of course, with populations of about 100,000 each, one cannot expect either the Guajiro or the Navajo to play a major role on the world stage, but they are regionally significant in their respective countries. Of great interest is why an occasional tribal group was able to meet militarily and economically dominant invaders, borrow important elements from their cultures, then integrate those elements into the still vital native culture. In the case of the Gua-



jira Peninsula and the Guajiro Indians, there are three answers to this question. First, the physical environment was not attractive to the invaders. Secondly, whenever the native culture was about to be overwhelmed, the vicissitudes of history operated in such a way as to relieve the assimilative pressures. Finally, and most subtly, the culture of the Guajiro was not only resilient and particularly attractive to its bearers but it also contained special elements that proved to have survival value. Extreme conservatism was not

one of them. The subsistence technology of the Guajiro has evolved into something entirely different from what it was before contact with Europeans.

The Guajira Peninsula extends northeastward from the Sierra Nevada de Santa Marta. The western and southern parts of the peninsula receive substantial rainfall and are suitable for farming. Considerable numbers of Guajiro live in this area, west of the Río Ranchería, but they, like those working around the city of Maracaibo in Venezuela, are hired help, a rural proletariat. East of the Río Ranchería, an area too dry for successful dry farming, and with only a few springs to irrigate tiny plots, the Guajiro pastoralists are the dominant, landcontrolling population. The thorn-scrub vegetation of both the flat western base of the peninsula and the hilly eastern extremity cannot sustain permanent settlements.

Projecting into the Caribbean Sea, the Guajira Peninsula was one of the first spots in South America to be visited by Spanish explorers early in the sixteenth century. Neither the land nor the small numbers of hunting, gathering, and fishing Indians invited conquest or settlement. The town of Ríohacha at the western border of the Guajira Peninsula proper was founded in 1545 as a base for exploiting brazilwood for dyestuff. The Spaniards established ranches and farms west of the Río Ranchería, but east of it, they left the Indians alone except for occasional punitive raids in retaliation for the theft of livestock.

For more than two centuries the river formed a cultural frontier across which European ideas and technology flowed without overwhelming the native cultural values. The Guajiro learned to care for cattle, sheep, and goats and to ride horses and burros. At times the Indians would cross the river to steal cattle from the colonial ranches; at other times they brought their own stock over to trade. As the Dutch established

themselves on Curação and



Aruba, they found on the Guajira Peninsula a population able to ignore Spanish prohibitions against foreign trade. Overland smuggling of luxury goods into the interior provinces of what was then New Granada began early and continues to the present as an economic activity in which the Indians participate significantly.

From 1770 to 1773 the Spaniards made a major effort to bring the Guajiro into their colonial polity. At Bahía Honda (a fine harbor at the northern tip of the peninsula, but an area almost without potable water), the viceroyalty established a settlement and gave Guajiro chiefs thousands of livestock in exchange for a promise to have their lineages adopt Christianity, establish permanent settlements, and obey Spanish law. Droughts followed, and to keep their herds alive the Indians migrated to scattered water holes in the interior. The settlement at Bahía Honda was abandoned.

Through the wars of independence and the civil wars that afflicted both Colombia and Venezuela during the nineteenth century, the Guajiro enjoyed a strategic position. They held large numbers of horses, which they could sell to one side or the other. The side that attempted to enforce too many alien laws and regulations on them risked the active opposition of the Guajiro in the next civil conflict. Only after 1930 were troops permanently garrisoned beyond the Rio Ranchería in Colombia, although the Venezuelan areas were more tightly controlled from the center at Maracaibo.

With their now fully developed pastoral system, which permitted

Her face darkened with charcoal to prevent tanning, a woman shovels salt. The saltworks, set up as a government project to reduce emigration, employs thousands of Guajiro.

extended migrations to find the water and pasture produced by the spotty and irregular rains, the Guajiro have developed the means of sustaining the largest possible livestock population on the peninsula. Not only is their present economy far more productive than the aboriginal one, capable of supporting several times as many people, but it also sustains more livestock and more people than would a modern commercial one keyed to permanent settlements and fixed property lines.

There are problems, of course. Livestock populations grow rapidly, and in areas of recurrent droughts herds must be sold outside the region for whatever price they will bring. Guajiro must leave the peninsula to seek employment. About 20,000 of them now live in Maracaibo, working as unskilled laborers. Thousands more have sought similar employment in the upper Rancheria and César valleys in Colombia. But in the peninsula itself the population remains almost purely Indian. There is no economic niche for immigrants other than missionaries, government officials, and a few businessmen for whom smuggling is an essential part of their operations. The latter, of course, need to be on the most respectful terms with the Indian population.

With its firm territorial base, the Guajiro culture can develop as autonomously as any culture in this shrinking world. While those Indians who emigrate may, in a generation or two, be fully assimilated into the Venezuelan or Colombian populations, those who remain in the peninsula show no evidence of losing their language or their basic Guajiro

orientation.

The material culture and the social system of the Guajiro are made up of a mixture of elements-some are pre-Columbian, some were adopted shortly after European contact, and some developed in recent times. The key element in their economy, the herding of cattle and other livestock, had to come from European sources. The pattern of strict matrilineal inheritance, however, has no European counterpart and must be aboriginal. The sharp social stratification based on the wealth of a limited matrilineage must have developed well after the adoption of a livestock-based economy. A Guajiro seeks to increase his capital (that is, the extent of his herds), making him an effective competitor in a capitalist world.

Within the Guajiro social system a number of seemingly incompatible features exist and function together. Property is inherited from one's mother's brothers; not from one's father, who will leave his property to his sisters' children. After marriage the husband will reside with his wife's family. On the other hand, wives are purchased, and a man who is wealthy enough can acquire several, dividing his time among different places of residence. Curiously, these seeming contradictions are not only acceptable to the Guajiro but also serve to strengthen the community economically, enabling it to resist the strong pressures to conform to the behavioral norms of the Colombian and Venezuelan populations.

Each Guajiro is a member of one of some thirty castas, or descent groups, and within the casta there are lineages of close relatives. Membership in a casta is always inherited through the mother's side; a man's children may belong to another casta. In any event, his sisters' children will inherit his wealth, although he is expected to provide for his children during his working life. At least for a number of years after marriage, a man will live near his wife's relatives. Should he become wealthy through inheritance or successful stock raising, his sisters' families are likely to gather around his home.

Property, which consists largely of livestock, is owned privately, and wealth varies within the casta from individuals who own nothing but their ragged clothes to those who own thousands of cattle and horses. While the

wealthy members of a casta would not let another member starve, the dependent individual must work without pay at a difficult or menial task, such as drawing cans of water for livestock from deep pits. A dependent retainer would find it almost impossible to buy a wife and is, in many ways, like a slave.

The casta has full responsibility for each of its members. Any injury to person or property must be compensated for, even to the extent of forfeiting a life if a satisfactory number of cattle cannot be paid. If an individual injures or kills a member of another lineage within his casta or a member of another casta, even accidentally, the head of the lineage must try to arrange a satisfactory payment. To deliver the offender's body would reflect on the prestige of the lineage, but a propertyless offender's misdeed might demand all the wealth of his lineage. Failure to agree on compensation has initiated blood feuds between castas that have persisted for generations. The significant aspect of this legal system is that, by making everyone responsible for everyone else in a lineage, there is strong social control. Anyone's misbehavior is dangerous to all.

From earliest childhood both boys and girls of families who can afford it are given livestock and taught that their futures depend on increasing their herds by attentive care. A man may give a few animals to his own children, but major gifts and, on his death, his estate, go to his sisters' children or to maternal relatives. Animals may be eaten or sold, but a growing herd is the mark of success. Because there is only so much pasture in the Guajira Peninsula, overgrazing and starvation of masses of animals during droughts are constant threats, of concern to both individuals and lineages.

As in all semiarid regions, there is great variability in rainfall and, consequently, pasture from year to year. Furthermore, rainfall may be spotty, and areas of hundreds of square miles may

THE GUAJIRA PENINSULA

CARIBBEAN SEA

Manaure Uribia

COLOMBIA

GULF OF VENEZUELA

SERRA VEYADA

DE SANTA MARIA

VENEZUELA

Maracaibo

be completely without forage. Permanent springs exist only around the mountains at the eastern tip of the peninsula and on its southern and western margins. Elsewhere, water for both humans and animals comes from transient puddles after rains or from hand-dug pits, some as deep as 100 feet. Water sources belong to castas, but normally each water hole is occupied by only one lineage. In droughts, however, many of these dry up or the water becomes too brackish for consumption. All animals in the region then gather around the few persisting water holes. At such times, overgrazing becomes acute and the herds of other castas, and then of other lineages, must be excluded. If they cannot be driven to another locality, the animals are sold to members of another lineage or to outsiders, often for no more than the value of the hides. The competitive pressure on an individual trying to build or at least maintain his herd is severe, and many fail. When rains come and pastures improve, those who were able to hold on to some stock quickly become richer.

The purchase price of wives is directly related to the wealth of their families. The absence of virginity will seriously reduce a bride's value; beauty, diligence, or amiability may add to it

slightly. It is to a man's advantage to buy the most expensive wife he can afford since he thus allies himself to a wealthy and powerful family. Brides have commanded a price of several hundred cattle, the sum being raised by gifts from maternal relatives. The price of a first daughter goes to the father; that of subsequent daughters goes to maternal relatives. Daughters, especially of the wealthy, are cherished and protected.

This is a system in which the rich are likely to become richer and the poor, poorer. Traditionally, the poor become retainers or enter some nonpastoral, less prestigious occupation, such as fishing, gathering wild plant products, or farming small subsistence plots in what is at best a marginal environment. More recently, they have emigrated to more humid and productive regions in Venezuela or Colombia. Trained from birth in the acquisition and maintenance of property, and with social and economic support from members of his own or a related lineage, a Guajiro is not a helpless immigrant even in the urban environment of Maracaibo. Although he may make a fair living abroad, his life's goals as an Indian can only be satisfied in the peninsula. The Guajiro who abandons his goals is usually assimilated into the lower class of the



country to which he has emigrated.

Such a class structure based on wealth could destroy the basic social unity of the Guajiro tribe, but two forces work against this. First, the wealth is not secure; the vagaries of localized drought and the failure of water holes may wipe out or greatly reduce the herds of even the largest livestock owner, but he is still responsible for his retainers and other members of his family. Second, upon the death of a wealthy man, a great deal of his capital is redistributed. Everybody is invited to his funeral, including members of other castas and even foreigners (I was invited to one even though I was simply passing through). If they have no other responsibilities, some people camp for as long as six weeks at the funeral grounds, consuming up to a third of the deceased's herds either directly or through sale to provide other food and drinks.

Because vagaries of the weather may force a group and all its herds to leave a failing water hole, houses receive little attention. The wealthiest Guajiro sling their hammocks from a pole framework sheltered by a roof of cactus ribs or grass thatching. Their crafts involve transportable goods. Weaving, the most developed craft, is practiced by women and their daughters, who enjoy

some status from their work. They use imported cordage and brightly dyed yarns, the latter to make the broad sashes worn by the men above their loincloths and the little purses carried by both men and women. From the cordage they make the *chinchorro*, the lacy hammock that is comfortable even at temperatures above 80° F.

By preference, men wear a loincloth supported by a brightly woven sash. A similarly brightly woven hat displays status. In towns, civil authorities may force the Guajiro to don trousers and shirts, garments that are often shed when they leave the town. Women's dress is more formal. The outer garb is the manta, short sleeved but falling to the ankles. The manta is brightly colored and of rich material if the family can afford it. On a woman's sandals, brilliantly dyed wool pompons, often more than three inches in diameter, mark the cadence of her walk. Women also wear, but do not display, valuable necklaces, which are handed down from mother to daughter and sold only under the direst circumstances. The Guajiro purchase these valuable goods from outside the peninsula, paying for them with hides, live animals, or wild plant stuffs such as divi-divi pods, which yield tannin. Since the mid-sixteenth century, the Guajiro have been economically independent but not economically isolated.

Guajiro customs, some concordant with the modern world and some quite alien to it, have served to reinforce the independence and integrity of Guajiro society. Smuggling is a case in point. With its long, sparsely occupied coastline, the Guajira Peninsula has been readily accessible to small smugglers' boats since the Dutch occupied Aruba and Curação early in the seventeenth century. After the countries became independent, the long border between Colombia and Venezuela, cutting across the southern side of the peninsula, enhanced smuggling opportunities. Latin American standards of sexual propriety allow a Guajiro woman, wearing twenty sets of fancy underwear under her flowing manta, to cross the border almost immune to search.

Some two generations ago, Levantine traders began to enter the Guajira to engage in and organize the smuggling trade. With acute insight, they bought and married the most valuable brides they could afford, thus allying themselves with the most powerful Indian families. Children of such unions have inherited status in Indian society and commonly choose to identify with it, while not abandoning their fathers' business experience and acumen.

Because of their Indian values and customs, the Guajiro identify with the upper, rather than the lower, strata of Colombian and Venezuelan society. Women's virginity or purity is prized and protected by male relatives, and its violation can institute a blood feud. Leaders of lineages stand bond not only for themselves but also for their relatives. The sight of stately Guajiro women striding down the main street of Ríohacha, a town at the western edge of the peninsula, bright pompons on their feet, has affected Colombian national consciousness. These are citizens to be proud of in their indepen-

The Guajira Peninsula is a hard land. Its inhabitants must struggle for survival, and actual starvation is often a threat. Fortunately, government relief projects, of which the great salt evaporation works at Manaure is the major example, are sustaining Indian society. The works are not mechanized and, for two or three months in the dry season, offer back-breaking employment to thousands of Indians of the retainer class. While they do not become wealthy, they are dissuaded from emigration and can return for most of the year to their unpaid pastoral employment. Hopefully, Guajiro society, changing as it has in the past and must in the future, will long endure, enriching the diversity of life in this hemisphere.

Living Links with the Past

by Rudolf and Marvin J. Schmid

More than 8,000 years of climatic history are recorded in the extremely narrow growth rings of bristlecone pines

On desolate mountaintops in the western United States grow the world's oldest organisms—the bristlecone pines. Many of these trees were seedlings when the pyramids of Egypt were being built, were mature trees at the time of Christ, and are now gnarled patriarchs with a life expectancy of perhaps another century.

These knotty trees, beautifully sculptured by time and the elements, their wood highly polished, live in such remote and inaccessible areas that, until seventeen years ago, their great age and beauty were known to only a handful of people. Then

the late dendrochronologist Edmund Schulman described them in a popular article that received national attention. Ever since, scientists and laymen alike have been drawn to the bristlecones by their age, beauty, grandeur, and research potential.

Bristlecone pines occur in only six western states. Most of the oldest and largest are found in the Ancient Bristlecone Pine Forest, a 28,000-acre region in the White Mountains of easternmost California, north of Death Valley. This preserve, part of the Inyo National Forest, was established in 1958 as a botanical area to protect our oldest living links with the past.

The life-span of a bristlecone pine may reach 5,000 years. The oldest known living tree, aptly named Methuselah by Schulman, is more than 4,600 years old and is still growing vigorously in Schulman Memorial Grove of the

Ancient Bristlecone Pine Forest. Even at 4,300 years of age, Pine Alpha, so named because it was the first tree to be dated older than 4,000 years, produces seed as viable as that of young, 1,000-year-old trees. The oldest tree discovered thus far grew on Wheeler Peak in eastern Nevada; this specimen, felled for research purposes, revealed an approximate age of 4,900 years, as determined by a count of its annual growth rings.

Bristlecone pines do not grow

Bristlecone pines remain standing long after death because their dense, resinous wood resists decay in the dry subalpine air. Wind-driven sand and ice polish—and sun bleaches—the gnarled remains.









The massive dead trunk of an old bristlecone pine may be misleading, as the tree can maintain itself with only a narrow strip of living tissue.

very high-sixty feet at most, but usually much less. The largest in girth is the Patriarch, a multistemmed tree with a circumference of thirty-six feet, eight inches, growing in the Patriarch Grove of the Ancient Bristlecone Pine Forest. The Patriarch is a relatively young tree, only about 1,500 years old. Most bristlecones average 1,000 years in age; only a few are older than 4,000 years. Bristlecone pines are considered young up to the age of 500; 50year-old trees are equivalent to

saplings of other species.

Until recently, bristlecone pines were regarded as a single species, Pinus aristata. In 1970, however, Dana K. Bailey, an amateur botanist, demonstrated that the westernmost bristlecone pines differ sufficiently in the structure of their needles and cones from forms growing in the distinct eastern portion of the tree's range to warrant a new species name, P. longaeva. P. aristata, or the Rocky Mountain bristlecone pine, occurs only in Colorado, New Mexico, and the San Francisco Peaks of Arizona; P. longaeva, the intermountain bristlecone pine, is found only in California, Nevada, and Utah.

Harsh ecological conditions, which favor the growth of bristlecone pines at the higher elevations of the White Mountains in California, are typical of all the areas in which both species are found. Average annual precipitation in the White Mountains is a low twelve to thirteen inches, most of which arrives as snow in winter. On any summer day, precipitable moisture in the air is only about half a millimeter, the lowest amount recorded anywhere in the world.

The White Mountains consist primarily of quartzitic sandstone and granitic bedrock. Most of the soils on the slopes have been abraded from these rocks, but there are also extensive outcrops of dolomite-an alkaline calcareous substrate of low nutrient but higher moisture content than the surrounding sandstone. The presence of these dolomitic or similar, nutritionally deficient calcareous soils inimical to the growth of other plants provides a competition-free haven for the slow-growing bristlecone pines. Consequently, these two species of five-needled pines have a patchy, or island, distribution. This ability to survive under poor soil conditions and low annual precipitation results in the extremely slow growth of the bristlecones and accounts for their longevity.

The vegetation in the White Mountains, a Great Basin desert range, is similar to that elsewhere in the southwestern United States at comparable altitudes: desert scrub below 6,500 feet; piñonjuniper woodland from 6,500 to 9,500 feet; subalpine forest and sagebrush from 9,500 feet to the upper treeline at about 11,500 feet; and alpine tundra above that.

The subalpine forest contains both bristlecone and limber pine (Pinus flexilis) in scattered open stands. At the lower elevations limber pine dominates the forest. Young bristlecone pines are intolerant of shading and cannot withstand competition by other trees, precluding their dominance on more favorable sites. Essentially pure, relatively dense, continuous stands of bristlecone pine occur only in areas of dolomitic soils. Outcrops of granite and extensive sandstone, which support predominantly sagebrush, surround the patches of dolomite.

Spring and the renewal of active growth come to the bristlecone pines in early May with meltwater from the winter's snows and higher temperatures. New needles, which have been dormant as winter buds during the long cold months, grow to add more green foliage for photosynthesis. Each year the tree increases in girth, if only by onehundredth of an inch, and new twigs and cones are formed.

At subalpine altitudes there are only three warm summer months during which a tree can produce the carbon compounds necessary for energy, growth, and reserves for overwintering. At least half of the summer growing season is needed to produce and store the reserves necessary to survive a normal winter. And additional reserves must be stored to initiate growth the following spring. In cool summers the tree lives on materials produced in that summer but grows in girth and height by using stored materials from the previous year. The short summer thus sharply limits the amount of carbon compounds that a tree can manufacture and store and, consequently, the amount of growth that a tree can achieve.

To survive under such draconian conditions, bristlecone pines have evolved several strategies. Needles may live twenty to thirty years; therefore, to replace fallen needles or to augment the present complement, a tree needs to produce relatively few needles each year. In addition, the longlived needles provide a stable photosynthetic capacity to sustain the tree over years of severe

Another strategy for survival involves the gradual death of bark and xylem, or water-conducting tissue, following the removal of part of the green crown by desiccating winds, drought, fire, lightning, and other natural means. This reduces the amount of tissue that the crown has to supply with nutrients through photosynthesis, so that an excellent balance is struck between the size of the crown and the amount of bark and active xylem. Instead of the entire tree becoming sickly with age, it dies gradually in a succession of adjustments. The remaining portion of the tree continues to live and is actually quite healthy. All of this results in a characteristic "slab growth" in which a narrow strip of living bark is maintained on a massive dead trunk. Pine Alpha, for example, is nearly four feet in diameter but has only a ten-inch-wide strip of liv-

ing bark.

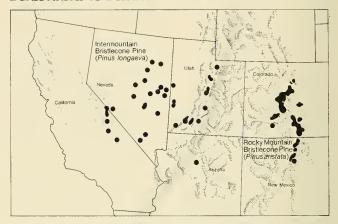
Insect, fungal, and bacterial invasions, which plague most plants, are virtually unknown to the bristlecone pines because their dense, highly resinous wood is strongly disease resistant. The dry air characteristic of the subalpine region can kill by desiccation, but it also helps preserve the trees from rotting. This is why bristlecone pines remain upright for hundreds of years after death. Only the decay of dead supporting roots, or their undermining by erosion, will cause a long-dead tree to topple.

The oldest, soundest trees grow in the harshest, most exposed sites. Trees growing under more equable conditions do not reach venerable ages because increased moisture encourages rapid growth and the production of less dense, less resinous wood, which is susceptible to disease and decay. The oldest trees are of the greatest scientific interest because of the information they can provide about past climatic and subsequent ecological fluctuations.

Trees in temperate zones usually have growth rings that reflect their age. Large, thin-walled xylem cells form during the rapid growth period of spring and early summer, and these contrast vividly with the small-diameter, thick-walled cells produced late in the growing season, when moisture conditions are less favorable. The structural dissimilarity between the late wood of one season and the early wood of the next season results in the occurrence of a growth, or annual, ring.

Since bristlecone pines grow very slowly, they have extremely narrow growth rings—from 100 to 200 per inch of wood. (In other words, these trees add less than an inch of wood to their diameter every hundred years.) The narrowness and climatic sensitivity of the annual growth rings, together with the great longevity of the species and the persistence

Distribution of Bristlecone Pines



of dead wood, make the bristlecone pine invaluable in dendrochronology, the science of measuring time by means of tree rings.

Soil moisture appears to be the primary limiting factor in the growth of a bristlecone pine, but any factor affecting the soil moisture regime of a site will directly affect the growth rate of the tree and, consequently, the width of its growth ring. Such factors include soil properties, snow accumulation, wind, solar radiation, and slope gradient. Trees growing under favorable conditions produce fairly uniform growth rings; dendrochronologists eschew them in favor of longer-lived, climatically sensitive trees growing under more severe conditions.

Many factors influence the width of a growth ring, and various methods are used to isolate the different environmental influences so that individual ecological effects can be studied. Sampling sites are chosen to illustrate a single limiting factor. This procedure, in conjunction with studies to determine the specific, limiting environmental influences of present climatic effects on tree growth, has provided the essential benchmarks for analysis of ancient growth rings.

The year-by-year sequence of wide and narrow growth rings forms a unique, nonrepeating pattern. To eliminate confusion between tree-induced and environment-induced variations in ring width, the actual width of each annual ring is reduced to a "ring width index." A series of such indices, as unique and nonrepeating as the original ring series, has been produced. This means that any two sections of wood within 1,000 miles to the east and south and 300 miles to the north of the White Mountains (the distributional range of both species of bristlecone pine) may be matched regardless of the ages of the trees being compared.

A bristlecone pine master chronology, which now serves as a standard of comparison for nearly all uses of the bristlecone ring record, was put together by comparing the patterns of tree ring indices of a great many tree samples. These samples represent both cross sections of felled trees and cores obtained from living specimens and standing dead snags with a Swedish increment borer. This invaluable instrument enables a scientist to obtain from a single tree, several cores, each about one-sixth of an inch in diameter, without in any way damaging the tree. Each core contains the history of the tree as recorded in its annual growth rings.

A living tree with this year's ring (called the bark ring) provides the starting point for establishing a chronology. Each ring is assigned an absolute calendar date. The ring pattern from another tree can then be matched with the first. Very slowly the chronology is extended back in time by comparing overlapping specimens.

Although the oldest living bristlecone pines are less than 5,000 years old, the chronology has been extended back more than 8,200 years by using specimens from long-dead wood. Large remnants of fallen trees may persist for 4,000 years since they are destroyed, not by decay and disintegration, but only by gradual erosion. The gathering of fallen wood by souvenir collectors is prohibited in the Ancient Bristlecone Pine Forest since such wood has the potential for further extending the bristlecone pine master chronology.

The greatest source of error in using the bristlecone pine for dating lies in incomplete rings. In years of severe environmental stress, many trees form a growth ring over only part of their circumference. Even in very bad years, however, at least a few trees in a given area form a very narrow, complete ring. Matching the ring patterns in cores taken from a great many trees indicates the presence and location of a missing ring.

The great accuracy of bristlecone pine chronologies is demonstrated by two series based on tree samples from the upper and lower reaches of the White Mountain distributional zone. The chronologies were compiled at different times by two sets of researchers, V.C. LaMarche and C.W. Ferguson, and their associates. The two series overlapped 5,395 years but disagreed by only two years. The missing rings were identified by detailed comparison of the two series, and two years were added in the chronology from the upper elevation. The two chronologies then matched perfectly!

A possible application of such precision would be in analyzing the wooden beams of an ancient building. If the wood used in construction came from the same general climatic area as the bristlecone pines, it may be crossdated with the master chronology to determine the age of the building. Fortunately, primitive people tended to use young, tall, straight trees for building, rather than trimming down large, gnarled old trees. The outer rings of the beam thus reflect the actual time of construction, and the entire ring series of the beam makes cross-dating possible. A sequence of about forty years is necessary for an accurate comparison. Dating of archeological sites by cross-dating, however, has had only limited application thus far.

One important application of bristlecone pine chronology involves radiocarbon dating. The accuracy of radiocarbon dates lies both in the technology involved and the validity of certain assumptions made concerning the concentration, through time and space, of radioactive carbon in the atmosphere. Careful radiocarbon dating of ten-year segments of bristlecone pine wood of known calendar age has shown that the concentration of radioactive carbon in the atmosphere has changed over time instead of being constant as previously assumed. Scientists have now developed a detailed calibration curve that correlates the real age, based on the bristlecone pine master chronology, with the apparent age determined by radiocarbon dating. Radiocarbon dates are thus corrected by means of the more accurate bristlecone pine chronology.

Reappraisals of many assumptions and theories in paleometeorology, archeology, and geology have resulted. Many archeological sites have been shown by dendrochronology to be 200 to 1,000 years older than previously believed on the basis of radiocarbon dates.

Partly as a result of these findings with the bristlecone pine, tree ring chronologies are being constructed in Europe and other areas. None, however, matches the 8,200-year chronology of the

White Mountain bristlecone pine.

The great and accurately determinable age, the persistent uprightness of dead trees, and the shallow, widespread root system combine to make the bristlecone pine useful in determining the rate of erosion and slope degradation at their elevation in the White Mountains.

Further information can be obtained by various statistical manipulations of patterns of growth rings. One interesting application is the determination of apparent altitude and locality of the specimen. The treeline in the White Mountains, for example, has been shown to have retreated over the past 1,000 years. The most deeply weathered and oldest remains of these trees are about 300 feet above their present upper elevation of growth. The remains can be dated to measure the amount of time that was required for the treeline to retreat. Tree ring dates thus indicate major and minor fluctuations in treeline, which may be correlated with climate.

The data obtainable from the bristlecone pines can be combined with other climatically sensitive variables such as pollen frequency, thickness of annual layers of silt, and isotope ratios of glacial ice to provide greater information for determining and comparing local and global climates of the past.

The bristlecone pines have survived for many thousands of years. Now the greatest threat to their confinued existence is the people who come each year to visit them. Methuselah, the 4,600year-old tree, is not even marked for fear souvenir seekers would vandalize the ancient tree. The record of the past that is stored within these trees and the beauty of their gnarled silhouettes against the subalpine horizon are too valuable, scientifically and esthetically, for us to lose them now. The bristlecones are reproducing sufficiently to maintain themselves, but we must generate enough respect for their place in the environment to insure that they will faithfully record the next millennium.

Rapid Rivers of Air

by Elmar R. Reiter

Mysterious and variable jet streams strongly affect weather, climate, agriculture, and aviation

Jet streams are ribbons of high-velocity air currents that undulate around the globe five miles and more above its surface. They have existed since the formation of our atmosphere but were not encountered until highaltitude aircraft were put into service in World War II.

On November 24, 1944, the first large-scale bombing mission in the Pacific theater using the B-29, the "superfortress," was launched. The code name for the mission was San Antonio. It called for the daylight bombing of well-defended industrial targets near Tokyo from an altitude of 30,000 feet by a force of 111 superforts. The heavily laden bombers, carrying almost 300 tons of bombs, took off from Isley Field on the island of Saipan in the Marianas and flew west of the Bonin Islands to skirt a typhoon that, according to reconnaissance reports, was moving in a northeasterly direction. Mechanical failure forced six bombers to turn back. As the rest of the command closed in on the Japanese Islands, the wind picked up steadily. The crews had been briefed to attack along a west-toeast axis. When they reached Tokyo, the superforts, flying at an altitude between 27,000 and 30,000 feet, were swept into a 120-knot wind, which gave them a ground speed of about 445 miles per hour. Bomb drift was difficult to compensate for with winds of such high velocity. Thirty-five aircraft had to bomb by radar, since an undercast almost completely obscured the target. Only twenty-four planes were able to bomb the primary target, a plant that produced most of Japan's combat aircraft engines. The rest had to unload on dock and urban areas.

The San Antonio mission had flown into the jet stream. For the first time in aviation and recorded meteorological history, those tremendous winds had fouled things up. Photographs taken by reconnaissance planes showed that only sixteen bombs out of the total load hit the target area.

The brutal force of the jet stream turned out to be a more formidable foe than enemy anti-aircraft guns. Jet stream winds, which nobody imagined could blow with such vehemence in the free atmosphere, caused the American High Command to alter its strategy completely. High-altitude bombing missions over Japan were abandoned, and on March 9, 1945, the first low-level incendiary raid was flown against Tokyo

At almost the same time, highflying Junkers reconnaissance airplanes of the German Luftwaffe encountered the jet stream over the Mediterranean. These planes were completely unarmed. Their enormous cruising altitude of almost 55,000 feet was their only protection against enemy artillery and fighter aircraft. At least one of these Junkers was lost in strong head winds of about 170 knots-comparable to the velocity of the most powerful hurricane winds-a speed that neither meteorologists nor pilots then thought possible.

Violent as they were, the winds encountered by military aircraft during World War II are not the strongest on record. On one postwar occasion an airplane measured a wind of 350 knots (approximately 400 miles per hour) over Tokyo. Winds in excess of 200 knots occur quite frequently at altitudes of six to ten miles above sea level in the core of

strong jet streams. The Japanese Islands are destined to hold the world record in high wind speeds at the base of the stratosphere. It is over that region that cold air masses moving southward from Siberia and China collide with warm air currents sweeping up from India, giving rise to excessively strong horizontal temperature contrasts, especially during the winter season.

Jet streams, like other milder winds, are caused by differences in atmospheric pressure, which in turn are caused by differences in temperature. It was known as early as the nineteenth century that the density of gases increases inversely to their temperature. Warm equatorial air is accordingly less dense than cold polar air. As a consequence, air pressure-which is simply the weight of the entire air column above an observation point-will decrease more rapidly with height in cold air than in warm air. At some level above the ground, where local disturbances have diminished, high pressure should prevail over warm subtropical and tropical regions, and low pressure should characterize the same elevation over the cold poles.

Air tends to flow from highpressure to low-pressure regions, much as water rushes down a mountainside. The earth's rotation, however, prevents the air from moving in such a straightforward way. As the earth turns, west to east, the air motion is deflected; in the Northern Hemisphere, it circles the low-pressure systems in a counterclockwise rotation; in the Southern Hemisphere, such air motion is clockwise. The rotation of air around low-pressure systems is called "cyclonic"; rotation around highpressure systems is known as "anticyclonic." Cyclonic and anticyclonic winds rotate in opposite directions.

With the sizable temperature differences between the Equator and the poles-more than 30° C. on the average, even during summer-and the ensuing pressure gradients in the free atmosphere, strong westerly winds would be expected to prevail over most of the globe. Some nineteeth-century research pointed out these westerlies, as well as other prominent wind systems. The west winds should be particularly strong where the horizontal temperature contrast between cold and warm air masses is particularly well developed. Such regions were called "fronts" by the Norwegian meteorologists of the 1920s, a term borrowed from the battlefields of World War I. No reports were then available about abnormally strong winds high above those fronts, however, since low clouds in their vicinity obscured the drift of the first weather balloons from the view of earthbound trackers, and man had not yet learned to fly even as high as the eagle. Jet streams thus remained undiscovered until World War II.

During the years following the war, meteorological research on the strange phenomenon of jet streams intensified. International meteorological cooperation, including the establishment of a dense-upper-air balloon sounding system, became the foundation of these efforts. Specially equipped and instrumented aircraft began to probe the atmosphere in systematic attempts to unravel the secrets of jet streams and to find ways to harness their power for aviation or to avoid their adverse effects, such as occasional severe turbulence. It was soon found that not one but several jet stream systems exist, all of which meander around the globe in the upper troposphere or in the stratosphere at lofty altitudes of five to thirty miles. According to the definition set forth by the World Meteorological Organization to distinguish these currents from other winds, a jet stream is normally thousands of miles long, more than a hundred miles wide, and a few miles deep. An arbitrary lower limit of about 100 feet per second is given as the wind speed along its axis.

Four separate jet stream systems, all of which circle the globe, have been identified and named

Winding around the earth in both hemispheres is the boundary between cold polar air masses and warm tropical air called the "polar front." The jet stream associated with the strong horizontal temperature contrast at this boundary is the "polar-front jet stream." In some places this polar jet, which blows from the west, is quasi-dormant and can hardly be distinguished on a weather map. In other places it becomes quite violent, sending surges of cold air southward in association with thunderstorms,



squall lines, and even tornadoes, or lifting moist, warm air along an active warm front, causing widespread precipitation.

A second jet stream known as the "subtropical jet," which also blows from the west, wends its way above the subtropical high-pressure belt and occurs only during the winter season. This jet stream circles the globe in three waves approximately 10,000 miles long. Whisks of clouds sometimes make this jet stream visible from the vantage point of a satellite.

During the summer season, a strong easterly wind blows over India and equatorial Africa in the upper troposphere, near the ten-mile level. This is the so-called tropical easterly jet stream. It is intimately tied to the rainy summer monsoon weather over those two continents.

Finally, there is the "polarnight jet stream," a latecomer in the history of jet stream systems, which circles around the pole of whichever hemisphere is experiencing winter. It moves through middle to high latitudes at heights of twenty to thirty miles above ground. This current plays an important role in the meridional transport of ozone, the highly toxic gas that shields the earth from lethal ultraviolet radiation. The polar-night jet stream blows from the west. It is caused by the temperature contrast that develops in the stratosphere between equatorial regions, which receive half a day of sunshine each twenty-four hours, and the polar regions, which are shrouded in darkness for up to half a year. During the summer, when the pole receives continuous sunshine, the horizontal temperature gradient in the stratosphere reverses. As a consequence, the polar-night jet stream disappears in summer, giving way to a milder and rather uniform flow of air from



The pattern of the two main jet streams—the polar-front jet and the subtropical jet—varies with the seasons. The subtropical jet, which occurs only during the winter, flows around the globe in three relatively steady waves. The polar-front jet, which occurs in winter and summer, is contorted into large-scale loops that change from day to day as surface weather alters. Sometimes the loops branch off and peter out. Cross-hatching marks probable areas of maximum wind speed.

the east, which does not assume jet stream velocities.

Aviators were not only the first to encounter the jet stream, they were also the first to realize its economic impact on commercial aviation. As trans- and inter-continental air travel became a way of life in the postwar world, jet streams were carefully mapped in the meteorological offices maintained by large airlines. Although jet aircraft can outfly most of the adverse weather effects that occur in the troposphere, they cannot escape the force of the jet stream. Even at airspeeds exceeding 500 miles per hour, the difference between a 200-knot head wind or tail wind is vividly felt in terms of extra fuel that must be carried or profitable extra payload that can be taken on.

Their economic influence is not the only effect of jet streams on aviation. The strong vertical wind shears—increases or decreases in wind speed at different altitudes that often exist in the immediate vicinity of well-developed jet streams can give rise to a violent overturning of air currents known as "clear air turbulence." This phenomenon got its name from the fact that it occurs far away from the clouds that experienced pilots always regard as being turbulent. Clear air turbulence, or CAT, strikes without warning. At times it can be severe enough to cause damage to aircraft and injury to passengers and crew.

In addition to affecting aviation, jet streams also influence weather activity near the earth's surface, particularly near the polar front. Jet maximums-centers of high wind speed-occur along the band of jet streams. These centers cause pulsations in wind speed: air flow accelerates as it enters such a speed maximum from the rear and decelerates as it exits from the front, almost as though the air were being forced through a nozzlelike constriction. The maximum speed zone itself migrates slowly eastward with the contorting jet stream band, at an average speed of twenty knots.

The accelerating and decelerating air motions associated with jet maximums in turn cause the outflow, or divergence, and inflow, or convergence, of air on a horizontal plane, which give rise to vertical air motions. As air flows out of what may thought of as a theoretical, or imaginary, vertical air column at jet stream heights, a decrease of pressure will result at the earth's surface-pressure being the total weight of the air column above the barometer level. If the outflow is strong enough, the fall of surface pressure will give birth to a cyclone. Friction at the earth's surface allows the air to rush toward the region of pressure fall instead of circling it cyclonically, thus filling the void at least partially. This convergent flow, together with upward motion in the troposphere and divergent outflow at jet stream level completes the picture of the atmospheric circulation in and near a cyclone. Since the rising air expands into an environment of lower pressure, it cools and causes the water vapor it carries to condense. Clouds, precipitation, and generally foul weather thus are characteristic of

cyclones.

Where convergence of flow occurs near jet streams, air is piled into the vertical column, thereby increasing its weight and causing surface pressure to rise. An anticyclone is then generated, from which, because of frictional forces, the air near the earth's surface flows outward. Descending motion prevails in this air column underneath the jet stream level. Since descent causes a compression and warming of air (as in a bicycle pump), the droplets in the clouds will evaporate as water vapor. Fair weather, therefore, prevails in anticyclones. As with cyclones, the development of anticyclonic weather is triggered by air-flow events in the jet stream region.

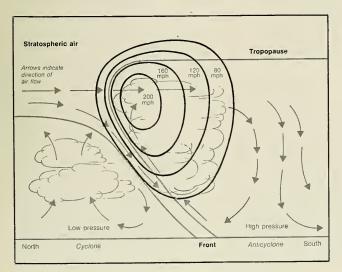
The vertical air motions induced by jet streams—ascending air in cyclones and descending air in anticyclones—not only cause characteristic episodes of foul and fair weather but also contribute greatly to a rapid and incessant stirring and mixing of the atmosphere. This interchange of air between the troposphere and the stratosphere explains why the gross chemical composition of the atmosphere, as far

as its oxygen and nitrogen content is concerned, is almost uniform over the globe. It has also saved us from choking to death on industrial effluents. The mixing leads to a dilution of pollutants over large areas and keeps their concentrations within tolerable-if not enjoyable-bounds. Rainfall then has a chance to wash most industrially generated pollutants from the global atmosphere before they irreversibly foul it up. The most effective washout of pollutants by precipitation is accomplished by largescale ascending air motions, which, as we said, are triggered by jet streams.

Atmospheric nuclear testing contaminated the troposphere and stratosphere with radioactive debris. The cleansing effects of precipitation usually remove atomic debris from the troposphere in a matter of days or weeks. Removal of debris from the stratosphere, however, depends on the vertical mixing of air near the jet streams, especially near the polar-front jet stream of temperate latitudes. It is not surprising, therefore, that these temperate latitudes suffer more than other areas from contamination by, and fallout of, stratospheric radioactive debris. Since most of the world's population lives in the jet stream belt of middle latitudes, human exposure to radioactive debris, mainly through the food chain, has to be viewed with concern.

The horizontal temperature contrast between cold polar and warm tropical air to a large extent controls the wind speed in the jet stream that overlies the polar front. This temperature contrast also determines the latitude belt in which the polar jet stream weaves around the hemisphere. In summer, when the contrast is relatively small (polar temperatures are near 32° F., tropical temperatures near 85° F.), the jet stream moves fairly far to the north. In the longitude sector occupied by North America, the stream then is found in Canada. During the same season, an easterly jet stream establishes itself over India and Africa at tropopause level (the top of the troposphere), controlling the rainy summer monsoon weather in these regions.

In the winter the temperature contrast between pole and Equator increases, ranging from about -40° F. in the arctic to 85° F. in the tropics. The jet stream belts are then pushed closer to the Equator. In North America, the



An artist's sketch of a cross section through a frontal system and a jet stream shows the movement of air and approximate wind speeds within the jet's maximum speed zone. The vertical scale is exaggerated by at least a factor of ten.

polar-front jet crosses the United States instead of Canada, and the subtropical jet meanders across the United States-Mexican border into Texas. The southward movement of these westerly jet stream systems occurs around the whole hemisphere, leaving no room for an easterly jet to develop over India and Africa. Instead, there are two westerly jet stream systems in the middle latitudes: the polar-front jet and the subtropical jet.

Over North America, Europe, and Japan, these two jet stream systems sometimes approach each other closely enough to interact, forming one enormously strong jet maxiumum, with wind speeds in excess of 200 knots, before they fan apart again. Such jet maximums give rise to the formation of cyclones, which bring in their wake howling winds, torrential rains, and blizzards.

Over the Middle East, these two winter jet stream systems split into two distinct, noninteracting branches. The polar-front jet wends its way across the frozen expanse of Siberia and China. The subtropical jet pushes to the south and crosses Pakistan, India, and Bangladesh, skirting the southern rim of the Himalavas.

The directional change in the jet stream flow and the change in associated weather patterns between summer and winter is most dramatic over the Indian subcontinent, where it takes place suddenly, within a few days. That these changes have been known in that region for centuries is attested to by the word monsoon, which is derived from the Arabic mausim, meaning "season."

As has already been mentioned, the subtropical jet stream lies over the subtropical highpressure belt. It is characterized by a sinking motion, which warms the air and brings fair and dry weather. The appearance of the westerly subtropical jet stream south of the Himalayas in late September, accordingly, marks the onset of the dry, winter monsoon in India. Toward the end of May, the subtropical

jet retreats almost as suddenly as it came during the fall. In a matter of days it jumps across the Himalayas and moves rapidly to the northern edge of the Plateau of Tibet, where it unites with the polar-front jet stream, ceasing to be a separate entity.

An easterly jet stream then establishes itself over northern India, marking the beginning of the wet, summer monsoon. Southerly flow, laden with moisture, invades the Indian subcontinent in the lowermost miles of the troposphere. Disturbances traveling aloft in the easterly jet stream induce ascending motions throughout the depth of the troposphere with concomitant drops in pressure at the earth's surface-the so-called monsoon depressions. The lifting of the moist air masses causes the formation of thunderclouds that release torrential rains-for example, Assam, a state in the extreme northeast of India, has an annual rainfall of almost 400 inches. The farmers of India, Pakistan, and Southeast Asia anxiously await the arrival, or burst, of the summer monsoon, which drenches their parched fields with life-saving moisture. Moisture means food, which will have to carry them over the dry season that starts in September.

The burst of the monsoon does not coincide with a fixed calendar date. Some years it comes several weeks later than anticipated, and fields planted in the expectation of rain then remain parched, cracked, and barren. Sometimes the westerly polar jet stream flow is erratic, and instead of staying in Siberia during the summer, it wanders over India, causing prolonged breaks in the monsoon associated with dry spells. These interruptions have disastrous effects on agricultural production, the livelihood of more than 600 million people.

Climate watchers have been keeping a careful eye on global temperature trends, searching for potential alterations in the temperature contrast between the poles and the Equator that could change the behavior, intensity.

and geographic latitude of jet stream systems. A general warming tendency was, in fact, experienced in the Northern Hemisphere from the 1880s to the 1940s. The jet stream systems of the middle latitudes were altered by these slightly warmer than normal polar temperatures, moving somewhat north and becoming somewhat weaker. Agricultural patterns and practices were also adjusted to the warming.

Since the 1940s, the polar temperatures of the Northern Hemisphere have dropped by a little less than 1° C. This does not sound like much, but it has had a noticeable effect on the atmospheric jet stream patterns. When such a cooling trend takes place in high latitudes, and tropical temperatures remain constant, it leads to a slight steepening of the latitudinal temperature gradient. That, in turn, causes the mid-latitude jet stream bands to shift slightly toward the Equator. The easterly jet stream that blows during the summer season over India and Africa will also be shifted slightly to the south and will probably be weaker than normal. This means that marginal areas of rainfall along the northern edge of this tropical jet stream belt will no longer be affected by the disturbances traveling along it. These regions will then receive less than their normal rainfall. That was the cause of the drought that befell the Sahel, or sub-Sahara area, with particular severity during 1972 and

A southward shift of the midlatitude jet stream belt and a weakening of the tropical easterly jet of summer might also have disastrous consequences for India. The summer monsoon might burst many days too late in the spring and retreat many days too early in the fall, cutting short the moist growing season. The weakened easterly summer jet might not be able to stave off penetrations of westerly winds over India during the summer. Prolonged breaks in the summer monsoon might occur, leading to drought. Decreased rainfall in India and in the sub-Sahara belt of Africa spells only one word: hun-

With famine and starvation threatening the well-being and political stability of the world, jet streams have suddenly aroused new interest. Since they are the cause of both drought and rain, new efforts are being made to understand their intricate mechanics and to forecast their behavior. The biggest electronic brains this country can muster and a vast amount of scientific manpower will be needed to unravel the secrets that jet streams and atmospheric circulation patterns still hold. The crucial questions are: Why do these systems change from year to year? Will they change even more than they already have since the 1950s and 1960s? What economic consequences will such changes bring, especially in the agricultural sector? Can we readily adapt to such anticipated changes or will they cause a major upheaval in our economic, social, and political systems? And last, but not least: Are these atmospheric changes triggered by human activity, such as man-made air pollution, or are they, rather, the manifestation of one of the many cycles through which the earth and its gaseous envelope have passed in the course of geologic time?

In a satellite photograph taken at an altitude of approximately 100 miles, a cloud band parallel to, and associated with, the subtropical jet stream extends across the Nile Valley in Egypt, over the Red Sea, and into Saudi Arabia. The Sinai Peninsula is visible at the lower left. The clouds are about four miles high.





Ascent of the Primates

by R.D. Martin

In the beginning, a small night creature scurried through the outer branches of an African tree

Ever since Thomas Huxley joined forces with Charles Darwin to establish the theory that monkeys, apes, and humans evolved from a common stock, the order Primates has attracted special attention from scientists of many disciplines. Field studies of these fascinating mammals have often had as a focus the hope that they may throw some light on human evolutionary history. Efforts by researchers to identify ecological and behavioral factors relating to the evolution of the primates have resulted in a vast amount of new information about man's distant relations.

Textbooks customarily divide the primates into two main groups: prosimians (lemurs, lorises, and tarsiers) and simians (monkeys, apes, and man). As their name implies, the prosimians are generally regarded as more primitive than the simians and, in some way, as their fore-



The slow loris of Southeast Asia, left, has evolved away from the ancestral primate trait of branch leaping to a specialized, slow climbing locomotion that probably helps it avoid detection by predators. Above, a reflecting tapetum behind the retina of the Senegal bush baby's eyes enhances the animal's night vision.



Two female and two juvenile Senegal bush babies, surprised while asleep in their nests, have fled to a vantage point on a branch. During the dry season, these animals sometimes sleep in groups amid the tangled branches of a leafless tree.

runners. Certainly, the evolutionary lines leading to modern prosimians branched off some time before the split took place between the monkeys, apes, and eventually, man. The "primitive" status of the prosimians, however, has often been taken too literally, and the evolution of the primates has been widely discussed as if present-day simians were actually derived directly from living prosimians.

It is only over the last two decades that the prosimians have been comprehensively studied in their own right, with an emphasis on their behavior under field conditions, rather than being treated as a largely uniform collection of primitive primates. In fact, recent study has emphasized that there is a tremendous variety in both structure and behavior in the living prosimians, which have undergone extensive evolutionary change since they parted company with the line leading to the modern simians.

Modern geographic distribution and fossil evidence indicate that the primates have always inhabited tropical or subtropical areas. One can therefore conclude that the primates generally are not adapted to continuous low temperatures and the added burden of marked seasonal variations in food availability. This is true of all the prosimians and of the New World monkeys today, although a few of the Old World simians (some species of monkeys and man) have recently managed to spread out into colder climatic zones. Among the prosimians, the lemurs, constituting three-quarters of the surviving prosimian species, are now confined to Madagascar. Their closest relatives, the bush babies, pottos, and angwantibos occur on mainland Africa, with two outlying loris species living in the Indian region and in southeast Asia. The tarsier is extremely limited in distribution, occurring only in rain forest areas on some islands in Southeast Asia.

Another major characteristic of the surviving prosimians is the predominance of nocturnal habits, contrasting with the typically diurnal habits of monkeys, apes, and man. (Only one simian, the South American owl monkey, is nocturnal.) Recent research indicates that there was probably a two-way split in the early stages of primate evolution, giving rise to the lorises and lemurs on one hand and the tarsiers and simians on the other. The former have retained the primitive mammalian characteristic of a moist, naked patch of skin, or rhinarium, surrounding the nostrils and joining the upper lip-these animals have been designated "strepsirhines." The latter, having lost this feature, have hairy skin between the nostrils and the upper lip-these have been assigned the name "haplorhines."

This seemingly trivial morphological characteristic, associated with the sense of smell because the rhinarium is related to the Jacobson's organ, may provide a clue to some of the fundamental factors that have governed the evolution of all primates. It can be reasonably suggested, for example, that the ancestral mammals were nocturnal, with an adaptive emphasis on smell rather than sight, and that this way of life was retained in the arboreal primates prior to the two-way split leading to modern

primates (strepsirhines and haplorhines).

After this split, the lemurs and lorises generally remained nocturnal with a well-developed sense of smell, while the haplorhine ancestors of the tarsiers and simians became diurnal at an early stage of their evolution. (There are good reasons to believe that the eyes of the common ancestor of the tarsier and the owl monkey were primarily adapted for diurnal life and that the enormous eyes of these two modern species have been reconverted for nocturnal vision.) The shift to diurnal life in the early tarsiers and simians would have favored the greater development of the brain, one of the main characteristics distinguishing the two halves of the primate evolutionary tree.

Given that nocturnal life seems to be associated with slow expansion of the brain in mammals generally, we can see why the lemurs and lorises are more primitive, over-all, than the tarsiers and simians, and why the tarsiers (secondary nocturnal forms apparently derived from a diurnal ancestor) are in many respects intermediate.

Among the lemurs and lorises, only the large Madagascar lemur species (for example, ring-tailed and sifaka) are diurnal in habits. The remaining lemur species (mouse, dwarf, and sportive lemurs) are nocturnal, as are all members of the loris group (bush babies, pottos, angwantibos, and lorises). In short, only a quarter of the surviving strepsirhine species are diurnal.

Using the argument that a widespread character in an animal group is more likely to be ancestral than a trait occurring in

STREPSIRHINES

NOCTURNAL

LEMURS LORISES

TARSIER NEW OLD APES MAN WORLD WORLD MONKEYS MONKEYS

ANCESTRAL PRIMATES

only a few representatives, we can conclude that the ancestor of the lemurs and lorises was probably nocturnal. The inference that the lemurs and lorises are all derived from a nocturnal ancestor is further strengthened by the fact that all lemurs and lorises, whether nocturnal or diurnal, have a reflecting layer, or tapetum, behind the retina, which doubtless evolved as an aid to nocturnal vision. Also, the reflective material of the tapetum consists of the same substance, riboflavin crystals, in those bush babies and lemurs that have so far been examined by scientists.

If, on the basis of this evidence, it is accepted that the lemurs and lorises are descendants of a nocturnal stock, it follows that the living nocturnal species are likely to be closer to the ancestral condition. Hence, study of the nocturnal forms should prove particularly valuable in interpreting the morphology and behavior of early primates. Luckily, the reflecting tapetum is of great value here; an observer moving through the forest at night with a head lamp can locate and follow these animals by keeping a continuous lookout for the reflections of their eyes.

In recent years, intensive field studies have been carried out on individual species by zoologists Jean-Jacques Petter, Pierre Charles-Dominique, Marcel Haladile, Simon Bearder, and the author. As a result, some information is now available for two-thirds of the approximately twenty nocturnal lemur and loris species. Data on the small-bodied mouse lemurs and bush babies is of special value, since the ancestral primate was probably also

small-bodied and similar in many of its basic behavioral and structural characteristics. A preliminary review of that information reveals several new insights into the behavior of the nocturnal primates and the evolution of the primate group in general.

Virtually all primates except man are arboreal at least part of the time, and virtually all primates other than man have both hands and feet with the thumbs and big toes widely spread and adapted for grasping. Certainly all the living prosimians are essentially arboreal; only the ringtailed lemur (Lemur catta) spends a significant proportion of its time on the ground. Again, taking the most widespread characteristics as indicative of the primitive condition, the ancestral primate was probably also arboreal, with grasping hands and feet.

Study of mouse lemurs and the smaller bush babies shows how such an adaptation may have been important during the early history of the primates. These small-bodied, nocturnal primates are typically active in what has been called the "fine branch niche," moving about with great agility in tangles of creepers, thin stems, and fine branches. Obviously, the larger-bodied lemurs and lorises must move around on broader supports, but it is in the fine branch niche that the smallbodied ancestral primates, like the smallest of their living descendants, probably circulated. In

such an environment, they could move with greater ease than many arboreal competitors.

A versatile combination of grasping and leaping in a tangle of fine supports would have favored many of the developments of primate evolution. Increased visual accuracy would have been required for leaping among a great variety of supports, and a visual memory would have been of great benefit. Development of vision would have involved expansion of the brain and refinement of cortical association areas in order to link vision with other sensory and motor components. The variation in diameter and orientation of the supports used would also have encouraged the development of a fine tactile sense and sophisticated feedback systems for control of the skeletal musculature. The nocturnal prosimians even have relatively larger, more forward-facing eyes than other nocturnal mammals, and the visual and motor areas of their brains are comparatively well developed. In other mammal groups, which developed adaptations primarily for branch running, claws were at a premium and leaping was less favored. Clawed branch runners do not require such versatile visual and motor systems and, consequently, have comparatively smaller

The high, pointed cusps and simple cusp arrangements of the molar teeth of early mammal fos-

Evolutionary Relationships among the Living Primates

An important split probably occurred during the early stages of primate evolution. The lorises and lemurs (strepsirhines) retained primitive mammalian morphological features adaptive for a nocturnal existence. The other primate groups (haplorhines) lost these features and evolved diurnal habits. The tarsier, which is considered an intermediate form, has evolved back to a nocturnal life.

sils indicate that the ancestral mammals subsisted largely on small animal prey, such as insects, for which shearing was more important than grinding. In the primates there seems to have been a general shift to the inclusion of more plant food in the diet. The lower cusps and increasing complexity of the molar teeth of early primate fossils indicate that the ancestral primate probably had a mixed diet of small animals and plant products, such as fruit, as is now the case with the living mouse lemurs, dwarf lemurs, bush babies, and lorises. Such a diet, however, is only common among small-bodied mammals-larger species usually have a more specialized diet. Because of their higher metabolic rate, small-bodied mammals must feed on items that readily yield large quantities of energy. Larger mammals, on the other hand, can exploit food sources, such as leaves, that provide a slower energy turnover. Also, it has been shown with bush babies, angwantibos, and pottos that-regardless of body size-only a standard quantity of insects is captured in the course of a night. This indicates that there is usually an upper limit on insect hunting.

With the larger lemurs there has been an increased emphasis on plant food, and several species are exclusively vegetarian. The sportive lemur specializes in a leaf diet to such an extent that it reingests feces derived from the cecum so that the products of bacterial action can be absorbed during a second passage of the vegetable matter through the gut.

The bizarre aye-aye (Daubentonia madagascariensis) has become specialized in an entirely

different direction. This largebodied lemur has a thin middle finger on each hand and rodentlike, continuously growing incisors used in the extraction of wood-boring larvae, a major constituent of its diet.

Such specializations in diet have in all cases been associated with pronounced modifications of the dental apparatus and the digestive tract. Only the smallerbodied nocturnal lemurs and lorises, which now exhibit a mixed diet of readily accessible small animal prey and plant products, have retained basically primitive dentitions. They all have molar teeth with essentially simple cusp patterns and a dental formula of two incisors, one canine, three premolars, and three molars on each side of the upper and lower jaws. Since dental formulas are typically reduced in mammalian evolution, while molar cusps typically become more complex in arrangement, the common ancestor of the lemurs and lorises probably had this maximum dental formula and simple molar

In fact, all of the small-bodied nocturnal lemur and loris species have a peculiar modification of the lower anterior dentition in that the crowns of the two canines and four incisors are all inclined horizontally to form a sixtooth "scraper." This can also be seen in more robust form in some of the larger lemurs, such as the ring-tailed; but in species such as the indri or aye-aye the dental formula has been reduced and the tooth scraper has been modified.

All lemurs and lorises use the lower anterior teeth for grooming, and this has been widely re-

garded as the major function of the tooth scraper, although most other mammals engage in grooming without requiring such specialization of their dental apparatus. Field studies of the smaller nocturnal forms have shown that there is another function that is at least as important and probably more influential. All of these species include plant gums in their diet, and the tooth scraper is used to scoop away fresh collections of gum from certain trees night after night. In some species, such as the mouse lemur (Microcebus murinus), gums are only a minor part of the diet during at least part of the year, while in others, gums are a major dietary component throughout the year. The fork-crowned lemur (Phaner furcifer) and the needle-clawed bush baby (Euoticus elegantulus) feed mainly on gums, with a small supplement of insects, and they have the largest tooth scrapers-relative to skull sizeamong the nocturnal strepsi-

Obviously the supplementation of the diet with gums could have been an important factor in the evolution of the tooth scraper, and the use of this device for grooming could have developed as a secondary feature. For a primate evolving in any subtropical area with marked alternating wet and dry seasons, the ability to obtain gum in the absence of abundant fruit and insect food would represent a valuable advantage. The presence of this specialized dental apparatus in many lemurs and lorises is just one example of an independent evolutionary specialization that has not occurred among the haplorhine tarsiers and simians.

Bush babies use a specialized form of locomotion called "vertical clinging and leaping." The generalized ancestral primate characteristics of grasping hands and feet and forward facing eyes provided a basis for the evolution of this unusual means of arboreal travel.

The lemurs and lorises also differ markedly from the tarsiers and simians in their reproductive biology. Whereas the tarsiers and simians have a highly invasive type of placentation, the lemurs and lorises have the least invasive type found among the placental mammals. In the tarsiers and simians, the outermost embryonic membrane is eventually bathed directly in maternal blood from the uterine vessels, following breakdown of the uterus lining. With lemurs and lorises, by contrast, no such breakdown of the internal uterine wall occurs.

Coincident with this, a female tarsier or simian of any given body weight will give birth to an infant weighing almost three times as much as the infant of a lemur or loris mother of similar body weight. This explains several observations of differences in reproductive behavior between these two groups of primates. Whereas the tarsiers and simians typically have only one infant at a time, which is carried on the mother's fur from birth onward, some of the smaller-bodied lemurs and lorises-such as the mouse and dwarf lemurs and the Senegal bush baby-may have twins or triplets and give birth to their babies in nests. Such species carry the infants by mouth when necessary; this is possible because of the infants' smaller size with respect to their mothers.

Presumably, nests are also necessary to keep the tiny infants of the smallest species warm during the night. With most of the larger lemur and loris species, no nest is used, and there is usually only one infant at each birth, which clings to the parent's fur. Nevertheless, the large-bodied

ave-ave builds an enormous nest, and the variegated lemur typically gives birth to twins, which are left in a nest of some kind. This may reflect retention of the ancestral condition from the small-bodied common ancestor of the lemurs and lorises. Here it is reasonable to conclude that the small-bodied ancestors of the lemurs and lorises had two or three tiny offspring and built nests, at least for breeding, whereas the ancestors of the tarsiers and simians, with their single, larger offspring, did not do so.

In addition, it is likely that in a subtropical zone with marked seasonality there might have been a selective advantage in developing relatively lightweight infants as an adaptation to the mothers' limited food supply. Thus, the reproductive evidence correlates with the evidence of the gum-collecting tooth scraper as adaptations enabling a small-bodied lemur or loris to cope with strictly seasonal conditions.

Some important new information has also emerged with respect to the social life of nocturnal prosimians. These primates have often been described as solitary in contrast to the typically gregarious simians. Although nocturnal prosimians are not often seen moving and feeding in groups, they have well-established patterns of social life involving overlapping home ranges in which communication between individuals is insured by occasional encounters, vocalizations, and scent marking. There seems to be a general pattern in which certain males have large ranges, each overlapping the ranges of several females. This has been observed with mouse lemurs,

sportive lemurs, various bush baby species, pottos, and angwantibos. A similar arrangement may also occur with the tarsier. In some cases the females actually sleep in groups during the daytime, and they may occasionally be joined by males. Since the sex ratio at birth for prosimians generally is usually one to one, there are often excess, peripheral males excluded from direct contact with females.

Such a basic pattern may well have existed with the nocturnal ancestral primates and would have provided a starting-point for the emergence of more complex, gregarious social behavior in the diurnal primates. This interpretation is supported by the gregarious social behavior exhibited by those lemurs that, like the simians, have become diurnal in habits. The ring-tailed lemur, for example, lives in social groups of about two dozen individuals, which move, feed, and sleep together. Indeed, there are many parallels between ring-tailed lemurs and baboons in the broad aspects of their social behavior.

Thus, contrary to what is often asssumed, the origin of gregarious patterns of social behavior of diurnal primates may well have been in a harem network rather than in a pair-bonding system. In fact, family groups or groups containing equal numbers of adult males and females are relatively uncommon among diurnal primates, whereas the tendency to harem formation and relegation of excess males to the periphery is widespread.

In this, and many other features, small-bodied nocturnal primates such as the mouse lemur and the smaller bush babies seem



The fat-tailed dwarf lemur, below, is dormant for most of the dry season and stores fat in its tail as a food reserve. Only the largest lemurs, such as the ring-tailed lemur, right, are diurnal. This exclusively vegetarian species is the only semiterrestrial prosimian.



to have remained close to the ancestral primate condition. The reason for this is that they have probably remained in an ecological framework similar to that in which the earliest primates evolved. Moving in the fine branch niche, feeding on a mixed diet of small animal prey and accessible plant products, and relying on versatility for survival, the early primates were stamped with certain characteristics that influenced the subsequent course of primate evolution.

Nevertheless, one must not forget that even bush babies and mouse lemurs have continued to evolve from this ancestral condition. The early primates had smaller brains than any living species, and their motor and visual systems were surely less sophisticated. Even bush babies and mouse lemurs are not, therefore, primitive primates, although they have apparently retained many characteristics that are close to the ancestral primate condition.





Kite Crazy

THE ART OF THE JAPANESE KITE, by Tal Streeter, John Weatherhill, Inc., \$20.00; 181 pp., illus.

During the first week of every May a monster kite is flown in the little village of Hoshubana, only an hour from Tokyo. It is a giant—48 feet high, 36 feet wide. Weighing almost 2,000 pounds its hones are made of stout bamboo, and 1,500 sheets of tough, handmade paper pasted together make up its skin. Two hundred bridle lines, each 100 feet long, are tied to its face, and the flying line is 3,000 feet long.

A fifty-man team, divided into three groups, flies this hape kite. Some hold it upright, while others dig in their heels and pull the line taut. As the wind reaches the great inclined face, the giant begins to stir, then to rise. The men holding the kite balance it until the very last moment, then run to safety; the rest race away, pulling the line with them, and, slowly, this giant rises straight into the air. Finally, there it sails, a mighty square cut out of the sky.





The kite at left has a highly stylized design of pumpus grass and full mean that was horrowed in its entirety from a playing eard.



"The flyers," Streeter tells us, "grit their teeth and rivet their eyes to the giant apparition they are loosing into the skies while across their faces a play of emotions-mostly strain, but also excitement, satisfaction, joy, and relief-marks the event. Curiously, although all of them have been certain of success, there is also an air of disbelief about them, a bit of innocent wonder, as though they had participated in the creation of a minor miracle."

The lifting of a kite, of whatever size, is always a miracle. Its flying always seems so unlikely, until there it is, often steady as a rock, in the air above us. And we have, somehow, made it possible. The thrill of kite flying is not childish. It comes from that precious sense of wonder that we adults, if we are lucky, still share with children.

Streeter has a very lively sense of wonder. He himself has been what the Japanese call tako-kichi ("kite crazy"), apparently, all of his life; then he went to Japan, a land that has been tako-kichi since the eighteenth century. There he traveled about, visiting famous kite makers and taking part in kite fights and kite festivals in Niigata, Hamamatsu, and Nagasaki. He talked with the last traditional kite master of the old Edo style, found the makers of the fantastic insect kites of Nagoya, and made friends with the sculptor Tsutomu Hiroi, who is as mad about kites as the author (himself a sculptor by profession) and who has successfully flown not only a 300-foot centipede kite but also his own raincoat, a garment triumphantly designed for that purpose.

All of this and more is told with enthusiasm and affection in this very handsome new book. Streeter is consumed by his perfectly reasonable passion, and this feeling is communicated with understanding and precision. He went to Japan determined to find

The cicada kite celebrates the insect whose song is a part of hot summer days in Japan.



The Gan Dancer evokes the power of an ancient race, the "Mountain Spirit People," or "Gans," who visited the Apaches, imparted great knowledge and then mysteriously left, returning to "the other side of the earth.

The elaborate costumes for this important ceremonial are fashioned after drawings of the Gans which they left in and around mountain caves as reminders to the Indians of the time when the Gans walked among

The Eagle Dance, as performed in the Pueblo of Tesuque (tes-oo-kay), is easily one of the most beautiful and intricate of all Native American sacred dances. The eagle's power is invoked in an energetic, swooping, diving dance that requires almost superhuman agility and strength of the young men chosen to perform it.

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"The Eagle Dancer" and "The Gan Dancer" are the first and second in a series

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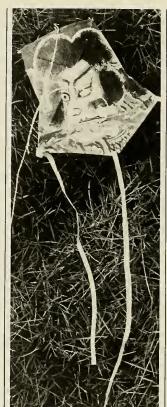
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feat, but it can be done. Like all romantics—and the fortunate possession of a sense of wonder is usually accompanied by a sharpened sense of romance—Streeter seeks out the past. Unlike many, he does not consequently belabor the present. He sometimes shows a typically elegiac regard for what has past ("Where there were once a hundred Edo kite makers, now there is only one"), but more often he enthuses at finding that so much kite flying is left, despite everything.

Streeter gives us extremely interesting chapters on early Oriental kites, on kite collecting, on how to make them and how to fly them, on what there is to read on the subject. Then he hears of something new, a mammoth centipede kite. "Can you imagine this incredible kite, a seven-hundred-fifty-foot-long paper serpent writhing through the sky? I was told about this kite by several very reliable people. I am sure it exists. But where?" A sense of wonder is rare, an ability to communicate it is rarer. I imagine that Streeter will be off to China-home of the monster centipede kites—as soon as he can.

Donald Richie, a resident of Tokyo, is director of Zokeisha Publications. Formerly the curator of film at New York's Museum of Modern Art, Richie served as film critic for the Japan Times.

GATHERING OF ANIMALS, by William Bridges. *Harper & Row,* \$12.50; 518 pp; illus.

The commission of the New York State Legislature that in 1888 created the parks in the northern reaches of New York City, stated as Conclusion No. 13 of its report that no park system could be regarded as complete without provision for botanical and zoological gardens. From this recommendation came the New York Zoological Society, the result of a collaboration between the public powers and the "wealthy gentlemen in New York City."

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ers, the Society (familiarly known today as the Bronx Zoo) undertook as its mission the education and amusement of the broad public that enjoyed contemplating large, exotic, and hopefully, healthy animals; the promotion of the study of zoology and ichthyology (through the acquisition of the New York Aquarium); and the preservation of the wildlife of the United States. Changing as the world around it changed in the years since its opening in 1899, the zoo has been and is, the author estimates, "the most innovative zoological park in the world."

Certainly the history of the Bronx Zoo delineates shifting attitudes toward wildlife. Strong support for the zoo in its formative years came from sportsmen of means who saw no incongruity in the exhibition of glassy eyed trophy heads and living collections. Then came field naturalists, trained to observe and record without killing; expeditions to distant lands for study or collection; and the publication of scientific monographs.

The names of many great, and sometimes autocratic, individualists march through Bridges's pages-among them, Henry Fairfield Osborn and his son Fairfield Osborn; Madison Grant; William Temple Hornaday, the indispensable director of the early years; Charles Haskins Townsend, director of the Aquarium; William Beebe; and Raymond Ditmars, the ever quotable herpetologist. Their struggles for the zoo, and sometimes with each other, make lively reading. Nor are occasional gaffes glossed over, such as the time a specimen of Homo sapiens was encaged and exhibited in the person of one Ota Benga, an African Pygmy left over from the Louisiana Purchase Exposition in Saint Louis.

Through the years the Zoological Society enjoyed the support not only of the "wealthy gentlemen" who put up most of the money but also of the general public, which passed by the millions through its gates, and of the press, which supported the zoo in substantive matters but showed an inveterate waywardness in spinning stories of monumental triviality that depicted animals as

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funny little people who happened to wear fur or feathers. Although there is perhaps more annalistic detail about dates, jobs, and administrative problems than the general reader might wish for, Mr. Bridges has lightened his text with revealing anecdotes, odd episodes, professional controversies, and excellent illustrations.

Gathering of Animals is described somewhat perplexingly as "an unconventional history." Yet Bridges is the zoo's emeritus curator of publications. His material is drawn from the Society's archives and the writings and reminiscences of participants in the zoo story. And the book's publication date coincides neatly with the zoo's seventy-fifth anniversary. The whole mise en scène seems official rather than unconventional. So do the silences. The necrology of dead animals is muted. The story of the international animal trade, a smelly business, is omitted. The only suggestion that the zoo concept itself has ever been examined critically occurs when Ella Wheeler Wilcox, the popular poet of the early 1900s, is quoted as saying that she didn't like zoos and would like to send all the animals back to their native homes. Mrs. Wilcox, however. was neither the first nor the last nor the best exponent of that point of view.

GERALD CARSON

SUPERSHIP, by Noël Mostert. Alfred A. Knopf, \$8.95; 332 pp.

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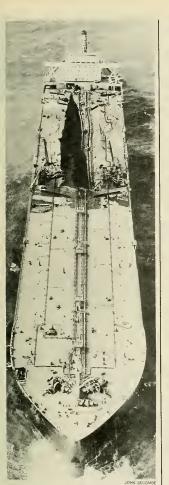
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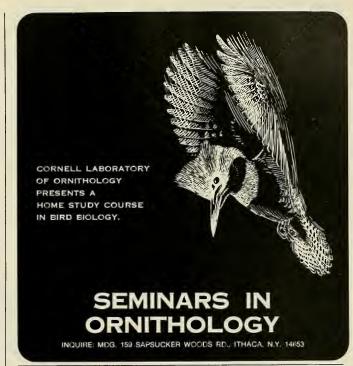
ners are cut in construction and operation. Personnel are sometimes incompetent. A majority of international tankers, even when United States owned, sail under essentially bogus "flags of convenience" (foreign registry in countries such as Liberia and Panama to dodge taxes and regulations). As the tankers wear out, they are handed down to less and less scrupulous operators.

A Canadian commission, investigating one tanker catastrophe, reported: "The standard of operation of the world's tanker fleets, particularly those under flags of convenience, is so appalling and so far from the kind of safety which science, engineering and technology can bring to those who care, that the people of the world should demand immediate action." The normal operation of tankers contributes heavily to the estimated 1,370,000 tons of oil discharged annually into the oceans by ships and to the additional 350,000 tons dumped in routine accidents-the aggregate posing a long-term threat to marine life and to the globe's basic ecology.

While there is no chance of stemming the proliferation of these VLCCs and ULCCs (Very Large and Ultra Large Crude Carriers), Mostert says much can be done to mitigate their menace. Double-hull construction can be required to lessen the danger of leakage in accidents. Twin-screw (propellor) rather than singlescrew design can be required to make them more navigable. Water-ballast tanks separate from oil tanks can be required to lessen waste oil discharges. A thorough survey of a ship's condition can be required when it changes ownership, to end hand-me-down degradation. Painfully slow ratification of international conventions upgrading tanker operation can be circumvented by imposing standards for admission to United States ports, as is done with passenger ships.

Otherwise, says the author, we may be facing incalculable grief and damage from "potentially the most calamitous craft that have sailed the seas."

GLADWIN HILL The New York Times





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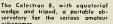
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Letters Continued from page 6 their breeding depends largely on a behavioral scientist's ability to understand the crane's behavior in their physical surrounding.

Until Dr. Cameron Kepler joined the Patuxent team in 1973. the program did not have a behaviorist. Since then, Kepler has separated the fifteen adult birds into five excellent pairs. Four of the remaining birds are females, and the fifth is a cripple of unknown sex. Soon after the pairs were separated from the flock situation, they assumed a closer association with each other and exhibited territorial dominance of their new confines. In 1974 two males produced viable semen, two pairs built nests, but unfortunately, no eggs were laid. We all have high hopes for their reproductive success in 1975.

Apart from the fifteen adult birds reared from wild-collected eggs, there are four other whoopers in captivity. One pair is at Patuxent; Crip, the only male ever to successfully father whooping cranes in captivity, is now at the San Antonio Zoo; and a son of Crip is now at the Audubon Park Zoo in New Orleans. Both these zoos have bred whooping cranes in the past and both are breeding exotic crane species at this time. I therefore believe it is advisable to attempt to mate the extra females at Patuxent with the two zoo males.

Cranes are not easy birds to start breeding in captivity. However, once they establish themselves and do start breeding, they are prolific birds for many years. I feel the Patuxent program is on the threshhold of breeding many whooping cranes. I encourage public support of the program, and I encourage the bureaucracy to allocate more funds to the endangered species program.

GEORGE W. ARCHIBALD, Ph.D. Director International Crane Foundation

THE AUTHOR REPLIES:

While Audubon's Roland Clement now rises to Ray Erickson's defense, he has twice in the past handed me the editorial ' Time to Halt the Taking of Wild Whooping Crane Eggs," which appeared in Audubon, September, 1969, two years after the endorse-



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ment mentioned by Clement. The editorial urges that no more eggs be taken until Patuxent proves that it can breed, raise, and release young whoopers—which, five years later, has not been done. And contrary to this public show of support, many Audubon officials, in private, are intensely critical of Erickson's work.

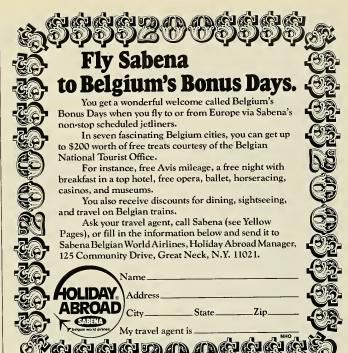
The birds now are separated by age, and since only one egg is taken from any nest in a year. this should prevent inbreeding. However, until recently several years' birds were penned together in a flock, with the avowed aim of letting them pick their own mates—which might have been

siblings.

Dillon Ripley suggests that Patuxent whoopers-if and when produced-be used to start a new, nonmigratory colony in the South, thereby circumventing the problems inherent in inserting captive-bred birds in a migratory wild niche. As Ripley points out, however, the gene pool of nonmigrating cranes is virtually gone: no pure nonmigrating stock remains. More important perhaps, Erickson says the Canadians will not approve using stock derived from eggs taken in Canada to start new populations that do not pass part of each year in Canada. I regret that Erickson's critics in the Fish and Wildlife Service may use my article to injure his program, but the assumptions of both political democracy and scientific methodology are that objective criticism is healthful. Erickson is a government employee, who runs a program of great public interest. Why should he be immune to criticism? He has avoided accountability to the community of his peers by failing, thus far, to provide any substantial report on his project in the scientific literature.

Finally, Ripley chides me—and I plead guilty, in part—for taxing Erickson for the deplorable fiscal constraints under which he and his associates must work. Yes, his superiors are cutting his throat. Yet part of the drill these days for a laboratory chief in the biologic sciences is to be able to touch the necessary money. Failure at this delicate, difficult, unpleasant task may mean failure

for the project.



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The Prevalence of Fives

You don't have to be five years old to ask fundamental questions. Here is a letter I received from a subscriber to this magazine:

I am now eighty-five and for as long as I can remember I have wished to know the answer to a certain question. I feel you might be able to tell me the answer.

Why is it that so many animals have five fingers and toes?

Why do so many flowers have five petals?

It intrigues me greatly and if I could only find the answer, I could die happy.

It is certainly true that practically all land vertebrates have five digits or vestiges of five digits on each forelimb. Paleontologists, tracing the evolutionary development of the horse, found from fossil remains that the precursors of the horse, the family Phenacodontidae, had five toes, but the early browser horse, Eohippus, had only four. A later horse, the grazer Merychippus, had a large middle toe with one digit on each side, which probably only occasionally touched the ground when the animal was running. Over millions of years, the middle toe developed into the hoof of the modern horse. Because of the way in which it was used, the hoof of the present-day horse is an enlarged fingernail of the middle digit. The four other digits, which serve no mechanical function, are vestigial.

In a similar way, paleontologists have deduced from fossil remains of early birds that the bone structure of the forelimb of the modern bird—that is, the wing—is a modification of an earlier five-digit ancestor and is particularly adapted for flying. Modifications of the five-digit form have taken place in many animal

species. To a lesser extent, humans and other primates show a modification in the digits with a clear-cut thumb, which serves for clutching (the prehensile thumb-

finger opposition).

As far as existing fossil evidence can show, the first fivedigit vertebrate was an amphibian. This creature, which lived some 400 million years ago, was probably the earliest vertebrate to invade the land. Fossil remains of a fish believed to be the forerunner of the first amphibians had a raylike skeleton in the forefin consisting of ten digits. Five of these digits are associated with three bones-the radius, the ulna, and the humerus-much as in the human forearm and upper arm, respectively. It is possible that the five small bones of the fish fin became vestigial in the amphibian. The forelimb served these animals less as a paddle and more as a support for land locomotion. Five is a good number for points of mechanical stability in a limb; a greater number of digits would be cumbersome and would, in my opinion, serve no useful purpose.

Another question is why the starfish has five arms. Most present-day echinoderms (the phylum of marine animals that includes starfish, sea urchins, sea dollars, and sea cucumbers) have a fivefold, or pentamerous, symmetry. One species of starfish-the sun star-has ten limbs and anotherthe sunflower starfish—has twenty. but these are multiples of five. Still another starfish species, Oeraster reticulatus, has either four, five, six, or seven limbs. But these examples are rare variations, and five is the general rule. There are fossil remains of starfish, perhaps the oldest of the echinoderms, that are not pentamerous, but these species have died out and none

exists today.

Echinoderms usually settle on the sea bottom where they cannot move easily to protect themselves against predators. For selfdefense they have five protective plates made of the mineral calcite. These creatures are most vulnerable just after metamorphosis from the larval stage, in which they also have fivefold symmetry, because at that time the protective plates can be dislodged simply by a nudge from a passing animal. It is therefore important that the sutures connecting the plates in pentamerous echinoderms be as few and as short as possible. Furthermore, there should not be lines along which the sutures can open up. David Nichols, the Oxford zoologist, has argued that the fivefold arrangement offers the pentamerous starfish the greatest protection and hence the greatest chance of survival.

In the plant world, the majority of flowers have five petals. Some composite flowers, such as the daisy, have many more petals, but microscopic inspection of the heads of such flowers shows that they are in turn composed of smaller flowers, or florets, that have a fivefold symmetry.

The flower is a plant's sexual reproductive system; its petals serve to attract insects, which bring about pollination. The fivefold symmetry appears not only in the petals but also in other plant structures. Botanists call a flower completely pentamerous if, in addition to five petals, it has five sepals (modified leaves of the flower), five stamens (the organ that produces the male gamete), and five carpels (the seed-bearing reproductive organs). Some fruits reflect the fivefold symmetry of the flower from which they were developed. If you cut an apple or a pear crosswise, you will see that the seeds are arranged as a fivepointed star.

The fivefold symmetry of these flowers probably has its origin in the spiral nature of the arrangement of leaves on stems. As I tried to explain in my article "The Spiral Way" (Natural History, August-September, 1974),

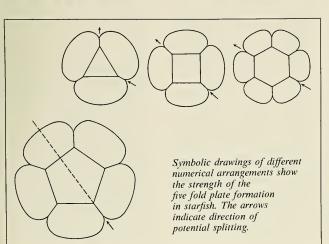
the number five, a term in the Fibonacci number sequence, arises naturally as a mechanism in leaf arrangement, or phyllotaxis. The same argument applies to the flower, which can be regarded as a short stem with modified leaves.

Fivefold structures have other interesting properties. For instance, equal-sided pentagons cannot be used as bathroom tiles. Unlike square, equilateral triangular, and equilateral hexagonal tiles, which fill an area compactly and completely, pentagonal tiles will create empty spaces.

One last thought on biological numerology-there are seven neck bones, or cervical vertebrae, in nearly all mammals. Only the manatee and the three-toed sloth are exceptions. Animals as diverse as the giraffe, the whale, the duckbill platypus, and man have seven neck bones. This phenomenon probably reflects a common ancestry from some mammallike reptile. For present-day mammals, at least, the top two vertebrae, the atlas-axis complex, are special in that they serve exclusively for rotation of the head. The remaining vertebrae-again, five-are concerned with flexing movements. Five links constitute such a nice flexible system that having more vertebrae would, it seems to me, serve no useful purpose. On the other hand, fewer than five links might make for a stiff neck. We cannot be sure of the relevance of these arguments without possessing the complete fossil remains of the mammals' immediate predecessor; such, unfortunately, is not the

case.

Gerald Oster is a professor of biophysics at the Mount Sinai School of Medicine of the City University of New York. The letter he has answered came from Mrs. Alice B. Steinhaus of Alhambra, California.



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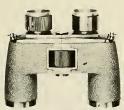
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And yet, the potato has only been a staple of the Western diet for about 200 years. It took two centuries to persuade fearful Europeans that this exotic relative of the deadly nightshade (and the equally suspect tomato) was fit for more than pigs. Even in Lord Byron's day, a dubious, aphrodisiac aura hung around it, for the poet, in Don Juan, speaks of "that sad result of passions and potatoes." By then, however, the potato had conquered the continent, thanks to clever promotion by the scientist Antoine-Auguste Parmentier, who is supposed to have given nosegays of potato flowers to Louis XVI and Marie Antoinette, and who otherwise popularized the mysterious tuber by keeping an experimental field outside Paris under ostentatious guard by day; at night, curious Parisians sneaked in, dug potatoes, and ate them with a greed reserved for forbidden fruit.

Once accepted, the potato established itself as the cheap source of food energy. It thrived in the cool climate and poor soil of Ireland and Belgium—thrived so well that entire populations came to depend on it for their survival. Van Gogh's "The Potato Eaters," a grim portrait of a Belgian family at table, is testimony to the wizened subsistence that the potato brought to expanding populations. A marginally valu-

able nutritional source (7.7 grams of protein per pound, some vitamin C; the rest, mostly water and carbohydrate), the potato did sustain life in the new industrial work force, giving them enough energy (279 calories per pound) to drag themselves to their dark, satanic mills. A dog's life, but still a life.

Then came the potato blight, the fungus Phytophthora infestans, which plunged Ireland into famine in the mid-1840s and forced millions of Irish to seek a less tuber-dependent life in the United States. In addition to the famous blight, other potato diseases, later pegged as viral, cut into productivity. And in North America, the Colorado beetle took its toll. The Detroit River swarmed with these insects in 1871. In 1877, the same pests, still flourishing, inspired a popular ditty: "Take care of your little potatoes boys, And all your tiny spuds . . . For the Colorado beetle's come To collar the jolly lot."

The situation was perilous. Elizabeth Browning wondered, in her long poem Aurora Leigh: "And is the potato to become extinct like the moly?" She had reason to worry, but by 1889 French scientists had developed the first effective sprays. The so-called Bordeaux mixture, copper sulfate and lime, was rivaled, appropriately enough, by the Burgundy mixture, copper sulfate and sodium carbonate.

At the same time, horticulturists experimented with disease-resistant hybrids. By the end of the nineteenth century, the cross-breeding of potatoes already had a long history in Europe. The Urpotato, an irregular, knobbly affair, had long since given way to the smooth-skinned varieties that are the ancestors of the potatoes we see today. Old records contain dozens of colorful varietal names,

by Raymond Sokolov

including the Irish "Protestant." ("We boil the Devil out of them," was the standard Irish explanation for that curious name.)

Potato scientists have also traced the genetic diversity of their chosen vegetable back to its origins in the northern Andes. Redcliffe N. Salaman, the dean of potato historians, wrote that all of the later varieties of potatoes in England could be traced to the "interplay of characteristics" derived from the two types described by Gerard and Clusius in the sixteenth century.

It was then that the potato first crossed the water from Peru to Europe and began its slow progress toward mass acceptance and universal cultivation. The first recorded confrontation between spud and Western man occurred in early 1537. A scouting party of Spanish soldiers from the expedition led by Gonzalo Jiménez de Quesada pushed their way eastward to the high village of Sorocota in northern Peru (latitude seven degrees north). The Indians fled at their approach and, according to the account of one Juan de Castellanos, the conquistadores found their houses stocked with maize, beans, and "truffles": plants with "scanty flowers of a dull purple color and floury roots of good flavor, a gift very acceptable to Indians and a dainty dish even for Spaniards."

Castellanos's enthusiasm notwithstanding, the first potato did not, apparently, arrive in Europe until the 1570s. It was first cultivated at Seville. Shortly thereafter, it crops up in Italy. The old story that Sir Walter Raleigh carried the first potato from Virginia to England seems erroneous altogether. And the best evidence chromosomal detective work by a Soviet group on Andean wild varieties, comparison with antique specimens in European herbariums, and research on

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early trade routes-makes it likely that the first exported potato came from the vicinity of Bogotá, was carried overland to Cartagena on the Caribbean and then shipped to Spain.

Modern botanical explorations in the Andes have turned up more than 100 wild potato types, growing from seashore to snow line. In Peru, potatoes range in color from pale gray to yellow to red, violet, and even black. In size, they run from tiny varieties no bigger than a nut to giants as large as a melon. Perhaps, given this wide choice, we have ended up with an inferior potato.

But it is certain that Europeans improved on Peruvian methods of preparing potatoes for the table. To begin with, the Indians use an insipid, frost-resistant variety of potato, which they then convert into a storable commodity called chuño by a five-day process that begins immediately after the harvest. The potatoes are spread on the ground and left to freeze overnight. Each day, the people stamp on them to squeeze out the water. The tubers eventually dry out but retain their shape and are eaten like bread. A more refined chuño, called tunta, is soaked for two months in a shallow pool of water and emerges white and ready to be converted to flour.

In societies with greater technical resources for storage and cooking, potatoes are normally eaten fresh. And they have been prepared by every known process: boiling, baking, roasting, sautéing, and deep frying. A universally adaptable dish, potatoes go well with nearly all kinds of food, from soup to fish. Russians ferment and distill them into vodka. Schoolchildren in India carry spicy potato snacks in their satchels, which they munch as eagerly as Americans do potato chips. To my mind, the highest point of potato cookery is puréed or mashed potatoes, which reach their ultimate airy sleekness when combined with an unsweetened cream puff dough, the mixture, or appareil, known as Dauphine. This rich culinary vehicle can be piped around the border of a serving platter and puffed in the oven or deep-fried as croquettes (see recipe below).

Fancy or plain, the potato has become a fact of everyday life in temperate climates because it is hardy and prolific. For the best yield, set small tubers in shallow boxes with the "rose" end (where most of the eyes are) up. These "sets" should be left to sprout in a light, warm place for two to four weeks in the early spring. Cut back the sprouts before planting. Two to three sprouts per tuber is ideal. Early potatoes are planted one to two weeks before the average date of the final killing frost. The ground should be friable, not still soaked from spring runoff. Dig furrows 4 inches deep and 18 to 24 inches apart. Leave a foot between tubers and set them over a thin layer of compost. Ten to twelve weeks later, you can begin to eat potatoes, although Earlies are not fully mature until July or August. When the tops die down, growth is complete.

In the meantime, periodic weeding is necessary, and it is a good idea to "earth up" the tops when they have grown to a height of six inches. That is, fork up the soil lightly and pull it toward the leaves so that it makes a mound around the stems, supporting them and protecting the new tubers below. Repeat this process four weeks later.

Plant a second crop of Earlies, a little deeper and more widely spaced, two to three weeks after the first crop. Three weeks later still, it is time to put in the main crops. These plants should be

Harvesting potatoes is stoop labor for the home gardener: bend, pull, and dig. Then leave the potatoes on the ground for a few hours to let the skins harden. Store in a cool, dark place; light turns them green. Eat them any time.

Potato Croquettes Dauphine

2 pounds potatoes, peeled and quartered

10½ tablespoons butter White pepper 3 whole eggs

4 egg yolks, beaten 10 tablespoons sifted flour

1 cup breadcrumbs, approximately

Oil for deep frying

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1. Preheat oven to 400 degrees.

2. Plunge potato quarters into boiling salted (1½ teaspoons salt per quart) water to cover and boil until tender but still firm. Drain the potatoes.

 Set potatoes on a baking sheet and dry them out in the oven for a few minutes with the door ajar. Then put them through a potato ricer into a mixing bowl.

 Beat 7 tablespoons of the butter into the potatoes. Season with salt and white pepper. Then beat in 1 whole egg and

all the egg yolk.

5. Prepare an unsweetened cream puff dough: Combine 1/2 cup water, I teaspoon salt, and the remaining 3½ tablespoons butter in a saucepan and bring to a boil. Remove from heat and add the flour all at once. Stir with a wooden spoon over medium heat until the dough dries out to the point where it no longer sticks to the spoon. It will also begin to leak butter. Then remove from heat, Stir in the remaining 2 whole eggs, one at a time, blending well.

 Beat the cream puff dough into the potato mixture. Blend well. You now have an appareil Dauphine.

7. Using two soup spoons, divide the appareil Dauphine into lime-sized spheres, or croquettes. Keep dipping the spoons in cold water to clean them. Collect the croquettes on a sheet of wax paper.

 Roll each croquette in breadcrumbs and set them on a clean sheet of wax paper.
 Sprinkle excess breadcrumbs

over the croquettes.

9. Shortly before you are ready to serve the croquettes, heat the oil in a deep-fry kettle until it smokes. Lower heat slightly and fry the croquettes, a few at a time, until they are golden brown. Drain in a bowl lined with paper toweling and keep them hot in a warm oven until you have finished cooking all the croquettes.

Yield: Six servings

Raymond Sokolov is a free-lance writer and food columnist.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The end of the winter season and the beginning of spring in the Northern Hemisphere occur on March 21 at 12:57 A.M., EST. This is the moment when the sun, in its apparent easterly movement among the stars, arrives at the vernal equinox, a point in the constellation Pisces. The sun now shifts its position over the earth from south to north of the Equator. From that time until late September, the daily path of the sun keeps it above the horizon, in northerly latitudes, for more than half the day.

The evening moon shows up about the 15th of March as a crescent in the western sky. From then until the end of the month, we will have some moonlight in the early evening hours. The moon will have grown to first-quarter by March 20, to the full moon by March 27. Waning thereafter, the moon then rises after sunset, progressively later nightly. It becomes last-quarter, rising about midnight, on April 3, and remains as a crescent in the morning sky until a few days before it becomes the new moon on April 11.

Stars and Planets Only Saturn appears on the evening star map this month. It is found in the south-southeast close to Pollux and Castor, the bright twin stars in Gemini. Moving west during the early evening, Saturn sets sometime after midnight. Venus appears low in the west in the early evening, shortly after sundown, but it sets a few hours later, before the time for which the evening map was prepared.

Mercury, Mars, and Jupiter (after March 22) are all in the morning sky, but only Mars is in position for viewing. Mercury and Jupiter rise before the sun, but too late in the twilight to be seen. Mars is low in the southeast at dawn, not too bright, but easy to find among the relatively dim stars of Capricornus and Aquarius around it.

March 15: The crescent moon will help in finding Venus this evening. Look below the moon, near the horizon in the southwest, about half an hour after sunset. On successive evenings, Venus will become more conspicuous, appearing higher at dusk, setting later.

March 21: The sun arrives at the vernal equinox, and spring begins in the Northern Hemisphere. The bright object near the moon tonight is Saturn. Jupiter lies in the same direction as the sun today (conjunction) and moves into the morning sky.

March 26: Another perigee moon, about 26 hours before the full moon, and again the effect of perigee will strengthen the normally

strong spring tides that accompany the full moon.

March 27-28: The bright star near the moon these evenings is Spica, in Virgo. The moon passes close enough to Spica during daylight on the 28th to cover the star (an occultation) in the sky over Antarctica. Occultation of Spica will occur regularly (every 27 to 28 days) for the balance of 1975.

April 6: Mercury and Jupiter will be very close at their conjunction, but they rise too late in the morning to be seen.

April 7: Mars will be near the crescent moon in this morning's sky, in the southeast about dawn. The moon is at apogee.

April 10: We will not be able to see Jupiter at its conjunction with the late crescent moon this morning.

April 14: The moon and Venus should make a pretty sight tonight, low in the west in the early twilight.

★Hold the star map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:25 P.M. on March 15: 9:25 P.M. on March 31; and 8:25 P.M. on April 15; but it can also be used for about an hour before and after these times.





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The Big Announcement

The 1975 Natural History Magazine Color Photography Competition

For the more than 5,000 wonderful photographers who lost last year—and for almost everyone else, too—Natural History Magazine proudly announces another chance to soothe your pride and lift your bank balance: the contest is on again.

We have changed the rules slightly so that even more people can enter. We have juggled the judges a bit, too (they turned down some great pictures), so that last year's losers might be this year's winners. And we've chosen a fascinating new place to send the grand prize winner.

The Competition: We've tried to keep it wide open: 1. The Natural World, including man. 2. Humor (extra points if you make

the judges laugh). 3. A Chronological Sequence, which may be up to five photographs of an event in nature.

The Rules: We've tried to keep them simple: 1. The competition is open to everyone except, of course, employees of The American Museum of Natural History and their kin, and last year's fourteen winners. 2. Competitors may submit up to three previously unpublished entries in each category. 3. Entries may be transparencies or prints up to 8 by 10 inches, and each must contain the name and address of the photographer, because keeping track of the thousands of entries is one big job. 4. For each entry, we would like to know the camera model used. 5. Include a selfaddressed, stamped envelope, since we do want to return your pictures to you.

The Closing Date: We've tried to keep it short. All entries should be postmarked no later than April 15, 1975—just like your income tax.

The Reward: Our munificence sometimes overwhelms us. Grand Prize is a round trip for two to Rio de Janeiro and the Amazon River. First Prize for each category is \$250. Ten Honorable Mentions will receive \$100 each.

More Rewards: All winning entries will be published in a special, color-crammed issue of Natural History and will be exhibited at The American Museum of Natural History.

Some Hitches: The decision of the judges will be final. Natural History acquires the right to publish and exhibit the winning pictures. And Natural History assumes no responsibility for transparencies and prints.

An important point: Pack your beautiful entries carefully and mail them to:

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A Final Thought: Good Luck.

The Other Announcements

The Javanese Puppet House Players will give a lecture-demonstration for adults on aspects of Asian shadow puppet drama. This will be held in the Education Hall at 5:00 P.M. on Sunday, March 16.

In the Hayden Planetarium of The American Museum of Natural History, "Sol" continues to explore the relationship between the earth and sun power. Sky shows begin at 2:00 and 3:00 P.M. during the week, with more frequent showings on weekends. "Sol" will run through April 7. Admission is \$1.75 for adults; \$1.00 for children.

Insects and Us, African Corridor, second floor, runs through early April. This exhibit explores the relationship between man and insects, the economic impact of insects, the role of insects in disease, and entomological research at the Museum.

Beginning March 1, the Department of Education of The American Museum will present nine six-week Workshops for Young People, designed for children from grades 4 through 7. Classes of 15 to 20 will be held in the Louis Calder Laboratory workshops; tuition fee, \$20.00.

"Ecology of New York City," Saturdays from 10:15 to 11:45 A.M.—rocks, plants, and animals of New York City will be explored.

"Exploring Archeology," Saturdays from 10:15 to 11:45 A.M., features films and a local field trip to explore the methods, tools, and laboratory techniques used to unearth man's past in the Americas.

"The World of Maps," Saturdays

from 10:15 to 11:45 A.M., introduces map reading and map construction.

"Understanding Animal Behavior," Sundays from 11:15 A.M. to 12:45 P.M., will explore the "whys" and "hows" of pet, laboratory animal, and wild animal behavior. Short trips to Central Park will provide a sense of the activities of common city animals such as squirrels and pigeons. "Indians of the New York Area."

"Indians of the New York Area," Saturdays from 12:15 to 1:45 P.M., will discuss the first inhabitants of the New York area and how they lived. The group will visit a local forest and a rock shelter where Indians lived; stone tool construction will be demonstrated. Other courses include "An Introduction to Mammals," "Fossils," "Soil Ecology," and "Exploring with the Microscope." For further information call the Department of Education (212) 873-7507.

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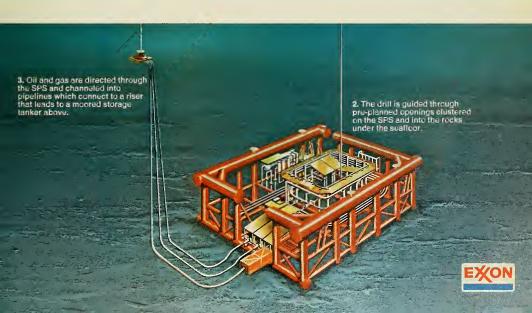
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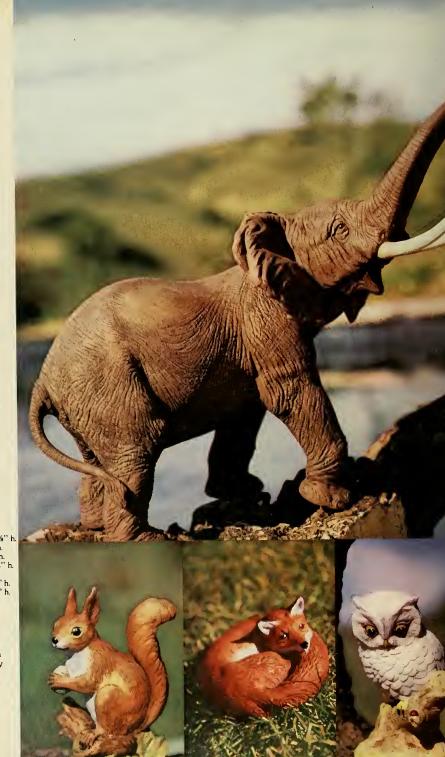
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Cover: A Bambara dancer in Mali imitates the deceitful behavior of a baboon. Animals are represented in many of the carved masks worn by these West African dancers. Photograph by Pascal James Imperato. Story on Page 62.

The Trans-Alaska Pipeline.

A report on the most remarkable private construction project in American history.

Far above the Arctic Circle on Alaska's North Slope lies the largest oil field in North America. The Prudhoe Bay oil field holds an estimated 10 billion barrels (one barrel equals 42 gallons) of crude oil.

For years engineers have generally agreed that a pipeline would be the most economical way to get the oil out of this wilderness.

In 1974 work began on the Trans-Alaska Pipeline System—the largest single construction project ever undertaken by private industry.



It took over one-half million tons of steel to make the 798 miles of pipe for the project. The sections are 40' and 60' long, 48" in diameter.

The route

The Trans-Alaska Pipeline System will be about 798 miles long—winding its way from Prudhoe across the rugged face of Alaska to Valdez, a deep-water port in southern Alaska.

The Pipeline must cross 3 major mountain ranges, including the Brooks Range, where it will snake through Dietrich Pass at 4,500 feet



The 798-mile Trans-Alaska Pipeline System may ultimately carry 2 million barrels of oil a day from Prudhoe Bay to Valdez.

elevation. It will cross 17 major rivers, including the Yukon, third largest in North America.

At the southern terminal point in Valdez, the oil will be loaded into ocean-going tankers and shipped to the U.S. West Coast.

80° below zero

Working conditions along the route are almost without parallel in the history of the industry. 40-mile-an-hour winds and temperatures down to 80° below zero can reduce human work efficiency by 90 percent.

27 Empire State Buildings

It will take over three years and nearly \$6 billion to build the Pipeline. This is the equivalent of what it would cost today to build 27 Empire State Buildings, or 3 Panama Canals.

Ownership of the Pipeline is held by eight companies, with Exxon Pipeline Co. having a 20 percent interest. These companies formed Alyeska Pipeline Service Co. to design and construct the Pipeline.

What's happening today

Right now, thousands of men and women are working on the Pipeline at many different camps spaced along the route. Employment will reach a peak of 15,000 workers at 29 camps.



The highest hurdle for the Pipeline will be the 4,500-loot-high Dietrich Pass in the Brooks Mountain Range.

The present schedule calls for the Pipeline operation to begin in the summer of 1977 at 600,000 barrels a day, with capacity of 1.2 million barrels a day shortly thereafter. Ultimately, the pipe may carry 2 million barrels a day. This important new source of oil will help America become more self-sufficient and less dependent on foreign oil.

For additional information on the Trans-Alaska Pipeline System, write: Exxon Corp., Dept. E, Box 1147, Ansonia Station, N.Y., N.Y. 10023.



Authors



Morton Fried, professor of anthropology at Columbia University, first became interested in the origins of tribes some 35 years ago when he was in college. Every Saturday during his college years, Fried worked in The American Museum of Natural History, mending Indian pottery and gluing shards together. The association of pottery with tribes initiated his long investigation of how tribes came to be. An expanded version of Fried's research will appear in his book, The Notion of Tribe, to be published later this spring by Cummings. Fried also studies clan and clan associations on Taiwan. an interest he developed while researching his doctoral dissertation on mainland China.



"I hope to encourage ecologically oriented anthropologists to actively contribute to the planning of agricultural development," says Susan H. Lees. Having spent four years studying changing farming practices in the Valley of Oaxaca, she has seen how modernization can upset ancient balances. Lees, who teaches anthropology at Hunter College in New York City, is now studying agricultural development programs in several Latin American countries. She hopes to expand her field studies to include areas of Africa and Asia with similar problems, "to refine our ways of isolating agricultural development programs and thereby avoid negative ecological and social consequences."



While teaching a course in phycology during the summer of 1970, Bradley Ewart collected a sample of pond water containing Volvox and other volvocines. Fascinated by these microscopic motile communities, he began to study and photograph them with the aid of special microscopic techniques. Formerly assistant professor in the Department of Biology at Northwest Missouri State University, Ewart has also taught scientific photography, including photography through the microscope. Ewart, who received his doctorate from Washington University in 1969, is now studying botanical history, including the history and control of fungal disease in plants.



Fred Bruemmer has been concerned with every aspect of life in the Arctic since his first trip to Lapland in 1959. A native of Latvia, Bruemmer emigrated to Canada in 1962 and has since spent roughly half of every year in the Arctic, photographing the flora and fauna and studying Eskimo life. His last article for Natural History, "The Northernmost People" (February, 1974), featured the Polar Eskimo of the Thule district of Greenland. Just returned from a photographic expedition to the Antarctic, Bruemmer will shortly be on his way for an extended stay with the Eskimo of Little Diomede Island in the Bering Strait. His fourth book on the far north, The Arctic, was published late last year by Quadrangle/The New York Times Book Company.

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A transplanted New Yorker who has lived in the Southwest since 1958, Louis J. Battan is director of the Institute of Atmospheric Physics and professor of meteorology at the University of Arizona in Tucson. He became interested in thunderstorms, hailstorms, and tornadoes while serving as a research meteorologist with the U.S. Weather Bureau in the late 1940s. A member of the National Association of Science Writers, Battan is the author of numerous magazine articles and more than ten books dealing with various aspects of weather and air pollution. In January he received the Second Half Century award of the American Meteorological Society for his research achievements.





Pascal James Imperato first saw Bambara dances with zoomorphic masks in 1967 when he directed a smallpox and measles eradication program in Mali. During his stay in that country, Imperato also researched the traditional medical beliefs and practices of its different peoples. Now first deptuy commissioner of the City of New York Department of Health, Imperato also teaches tropical medicine at the Cornell University Medical Center and at the Downstate Medical Center. His first article in Natural History, "Nomads of the Niger." appeared in the December, 1972, is-

Although his formal training was in classical philology and he spent ten years teaching classics at various universities, Sam Abrams now devotes his time to free-lance writing, animal husbandry, and gardening. For the past six years he has lived in northern New England, where, until recently, he was a member of an agricultural commune. Abrams edited Noose, a private poetry newsletter, and his poems have been published in many magazines, including Chelsea Review, The Nation, and Green Mountain Review, as well as in various anthologies. His essay "Big Sur Storm" appeared in the August-September, 1970, issue of Natural History.



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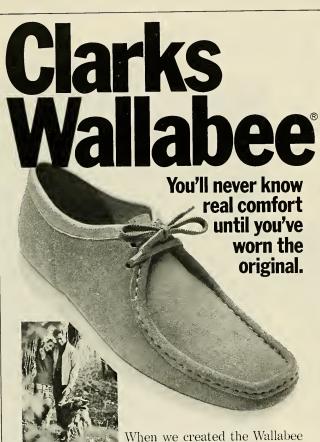
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Announcements

A Legacy of Lepidoptera: Titian Ramsay Peale. The original manuscripts and illustrations of American Lepidoptera of the 1830s and Butterflies of North America of the 1870s, by the American naturalist Titian Peale, will be on display in the Rare Book Room, fourth floor of The American Museum of Natural History through the fall of 1975.

Puppets: Dance and Drama of the Orient continues in Gallery 77, located on the first floor of the Museum, through April 20. This stunning exhibit is a major guide to the centuries-old role of shadow theater and other forms of puppetry in traditional Oriental drama. In conjunction with the above exhibit. Enchanting Shadow Productions will demonstrate Chinese Shadow Theater on Friday. April 11; Saturday, April 12; and Monday, April 14; 3:00 and 4:00 P.M. in the People Center. On Sunday, April 20, at 2:00 P.M. in the Museum's Auditorium there will be a performance of Asian Dances featuring classical dances of India by Manjusri, two Korean mask dances by Won-Kyung Cho, and dance scenes from Chinese opera.

In the Hayden Planetarium, "Sol"—an exploration into the relationship between life on earth and solar energy—continues through April 7. "Between the Planets" opens April 8 and runs through June 30. This show will examine major planets and satellites of the solar system. Sky shows begin at 2:00 p.m. and 3:30 p.m. during the week, with more frequent showings on weekends. Admission is \$1.75 for adults and \$1.00 for children.

In Search of Peking Man, Museum Showcase, second floor, Roosevelt Memorial Hall, continues through April. This exhibit uses casts and photographs of the digging site at Choukoutien to recreate the discovery of the missing fossils. Peking Man is believed to have lived about 500,000 years ago.

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The Myth of Tribe

by Morton H. Fried

Did the state come from the tribe or the tribe from the state?

Early in the nineteenth century, when American Indians were fast losing their land to westward-moving pioneers and zealous United States military incursions, Tecumseh, the eloquent Indian spokesman and warrior, and Gen. William Henry Harrison, then governor of the Territory of Indiana, met at Vincennes, the territory's well-garrisoned capital. The meeting had been requested by Tecumseh to enunciate the Indian position concerning the occupation of Indian lands by the encroaching whites. For years Tecumseh had struggled to convince not only his fellow Shawnees but all Indian populations that they should unite in the face of the whites rather than continue their separate ways.

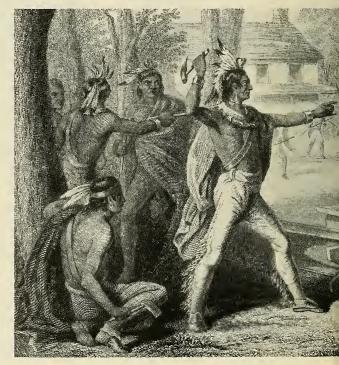
As part of his speech at the Vincennes meeting comes down to us, Tecumseh said, "The only way to check and stop this evil, is, for all the red men to unite in claiming a common and equal right in the land, as it was at first, and should be yet; for it never was divided, but belongs to all, for the use of each."

Harrison, who had long struggled against the Indians in order to open Indiana to white settlement, reacted strongly. He said that Indians did not make up one nation, that they had always lived in separate tribes, and that each tribe could do with its land as it pleased. This declaration so

enraged Tecumseh that he tried to tomahawk Harrison on the spot but was restrained by Harrison's soldiers. The outcome of this meeting, however, was partially responsible for the Battle of Tippecanoe in 1811, in which the Indians suffered severe losses. And the outcome of this battle contributed to Harrison's election as the ninth president of the United States.

From stereotyped cowboy and

Indian movies to the issues of tribal land claims, most of us, like Harrison, have been so accepting of the concept of the tribe that we have not questioned its historical validity. We assume that tribes are a form of society so ancient that their origins have been lost in time. Social scientists, including most anthropologists, think of tribes as merely a stage in the evolution of political systems, occurring between family



and the appearance of organized governmental bodies.

I disagree. I think there is ample evidence to indicate that states created tribes rather than having evolved from them. I believe that tribes first came into existence perhaps five or six thousand years ago. Considering that human culture may be as much as three million years old, the tribe must be regarded as a recent invention. Most tribes are



much younger; some may even have been formed in the present century.

Of Latin origin, the word tribe probably entered English through Old French. Earliest mentions of the word in the thirteenth and fourteenth centuries were largely confined to biblical references, such as "tribes of Israel." As time went on, usage flowed in various directions. Shakespeare showed some fondness for the term, applying it derogatorily to Shylock and his people. He also used it to place Othello and, at least once, referred it to American Indians. A bit later, tribe designated a formal unit in biological taxonomy, falling between family and genus. The term was also used to refer to odd assortments of people, like "the scribblers' tribe."

Although many anthropologists have now become wary of the word tribe, it has steadily gained popularity in common speech and writing. But curiously, it did not become a general term of reference to American Indian society until the nineteenth century. Previously, the words commonly used for Indian populations were nation and people. Indeed, even when the word tribe was used in the early nineteenth century, it was often coupled with the word nation, as in "tribe or nation."

Sometime in the first half of the nineteenth century, however,

Angered by Gen. William Henry Harrison's claim that Indians had always lived in separate tribes, Tecumseh tried to tomahawk him. nation and tribe became distinct. Nation referred to the largest or most favored Indian populations or those considered somehow more noble, as in "the Iroquois Nation" or "the Algonkian Nation." At the same time, tribe assumed an increasingly pejorative meaning, indicating, as one of the six definitions of tribe to be found in the Oxford English Dictionary puts it, "a race of people; now applied esp. to a primary aggregate of people in a primitive or barbarous condition, under a headman or chief."

As the general meaning of tribal organization became more closely associated with primitive society, nineteenth-century anthropologists such as Lewis H. Morgan and Edward B. Tylor studied the tribe as a starting point in the analysis of social evolution. Sociologists such as Herbert Spencer and Emil Durkheim also saw tribes this way, as did Marx and Engels.

This identification of tribalism as a primitive stage in political evolution has had some interesting consequences. Because of the association of the tribe with savagery or barbarism, many articulate people in so-called Third World countries now vehemently object to any characterization of their societies as tribal.

On the other hand, not all those designated as tribal resent the characterization. Some Indian populations in this country and in Canada are happy to apply the term to themselves. Vine Deloria, a Native American writer, does not hesitate to speak of American Indian tribes. Indeed,

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he believes that American society is in deep trouble, from which it "could save itself by listening to tribal people." Behind this thought is the notion that tribal society is warm and humane, in contrast to the cold, commercial, and bureaucratic traits of modern society.

Beyond the qualities of barbarism and savagery, most people now think of a tribe as a united population that speaks the same language, traces descent from common ancestors, and reproduces among its members. According to the stereotypic view, each tribe lives in a certain territory and defends it against outsiders. This view assumes that tribes are led by chieftains and that tribal members share the same economy and religion. Alas! Before the evolution of the state such cohesive groups never existed.

However the thought may disturb us, all human societies larger than the immediate band or village were of the vaguest dimensions and boundaries, with memberships that shifted for any number of reasons. Admittedly, this is a difficult, perhaps impossible statement to prove. Archeology has produced little hard evidence of political structures prior to the emergence of specific states. And evidence of shared cultural traits spread over certain geographic areas does not in itself constitute proof of the ancient integration of populations on a tribal level. Confronted with such evidence, archeologists usually turn to the findings of cultural anthropologists for guidance. Many anthropologists study societies that depend for subsistence on hunting and gathering or on simple types of plant cultivation or animal domestication.

From information about present societies, archeologists can fairly reasonably reconstruct the cultural traits of past societies. When the findings of anthropologists are thoroughly examined, the most cohesive units of simple populations are apparently bands or villages, not tribes. When anthropologists do discover a unified number of bands or villages, such as fits the conventional definition of tribe, it can be readily shown that such organization has

been imposed by encroaching

Because the bands and villages of prestate societies were so formless (or seemed so for the purposes of colonial powers, including the expanding empires of the ancient world), the encroaching states had to transform them. As a precondition for their manipulation, exploitation, and, ironically, their expropriation, they had to be pinned down. By formalizing what had always been casual social divisions, colonial powers created tribes and virtually assigned them definite, bounded territories that could then be removed from native populations by treaty, purchase, or even outright theft. This was precisely the state of affairs against which Tecumseh fought.

Since 1946, American Indians have been awarded millions of dollars in claims for past dispossession. These awards are based on a United States Supreme Court decision that declares such compensation valid in cases where Indian title rested on tribal use and occupation of an area, to the exclusion of others, since time immemorial. Under these circumstances, American Indians have vested interests in the concept of tribe and are obliged to provide the deepest

I do not wish to deny Native Americans their rightful claims. Rather, it seems ridiculous to me that claims for indemnification

history for it.

should require acceptance of a myth to satisfy the legal preconceptions of an infringing state. These preconceptions include both the acknowledgment of

permanent tenure and the idea of sale and alienation of land.

William Penn had an outstanding reputation among early European settlers of America for being fair to Indians when negotiating land deals with them in what is now Pennsylvania. Penn seemingly acted on the assumption that English notions of land ownership were naturally implanted in Indians as well. But when advising his agents on how to act when dealing with the Indians, he expressed his actual belief that Indians did not respect land ownership. He warned his agents to be wary of the Indians,

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"for they will sell one another's [land] if you be not careful."

Just as tribes did not hold land in accordance with European concepts of ownership until they learned to do so through the colonial experience, so they did not wage wars to maintain or enlarge their boundaries until they learned this from encroaching states. So removed was most American Indian warfare from a quest for territory or other economic gain, that various anthropologists have theorized that such warfare was a form of game or sport or was of primarily religious significance. Ethnographic evidence suggests that before the formation of tribes as a consequence of earlier appearances of the state, military organization was poorly developed and generally undisciplined. After contact with an invading state, however, native populations learned military organization and tactics and sometimes became fierce antagonists until vanquished through superior technology.

Ethnographic studies reveal that populations are unlikely to have had any regular economic organization on a scale that can be called tribal. Almost all significant economic activities-production, distribution, and consumption-were carried out at the level of the household, the village, or the basic migrating group. Intervillage invitations to share some economic activities usually brought together groups of relatives, often including inlaws, who lived in different places, not too far apart. This did not mean that an entire population would act in concert, but it often meant that people from separate groups, sometimes considered as different tribes, would act together. The same observations apply to the conduct of religious rituals and ceremonies.

Another reason for suggesting that tribes were made and not born is that the names by which most of them are identified are of suspicious origin. A large number of tribal names come from languages unknown to the population concerned. These foreign names usually reflect instances in which one population came into contact with another; often the names are insulting and demean-

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ing to those to whom they are applied. In central Brazil, along the Madeira River, which flows into the Amazon, there is a people sometimes known as the Parintintin, a word that, in the neighboring Mundurucú language, means "the stinking people." A Siberian people formerly known as the Samoyed despised that name because it was derived from the Russian word for "cannibal." These people prefer to be called Nenetz, "the people," in their own tongue.

Tribal names, then, do not confirm the existence of aboriginal tribes. They testify, instead, to relations between populations or between fragments of populations. Most such names are new and date from contact with an intrusive state. American Indian tribes often have suspicious names such as Crow, Blackfoot, Digger, and Creek. to list just a few. Older names tend simply to be words in local languages meaning "the people," or "the human beings." Such words do not apply to narrowly defined tribal populations, but to hazy aggregates that tend to shade off into other designations.

If tribal names have a false ring, so does the belief that members of a tribal population are descended from common ancestors. All societies play genealogical tricks and commit genealogical frauds. Constructing and misconstructing their origins, people blend myth and reality into firmly held beliefs.

Since genealogies are often used to explain and validate the distribution of rights, privileges, duties, and obligations within a society, social scientists regard them as charters of social life. Genealogies act as charters because they provide the members of a society with positions in that society, thereby legitimizing the relationships and content of everyday activity. Far from hampering such usage, the mythic quality facilitates manipulation and provides a major means of adjusting to various kinds of social change-both small and large. By manipulating genealogy or playing more broadly with myths of descent, a population may seek to influence its general standing in the world.

Few anthropologists have pursued this theme as cogently as John Gwaltney in his study of the genealogical myths of the Shinnecock Indians of eastern Long Island. Historical sources reveal that the modern Shinnecock possess an amalgam of genes derived from Native American, African, and some European ancestors. For purposes of social mobility, however, the generally dark-pigmented Shinnecock prefer to ignore or deny the black component of their heritage while stressing the Native American component. After all, notes Gwaltney, "The plain truth is that . . . a skin reckoned as black by most whites is . . . the emblem of exclusion from wealth and privileged status." So it is that by manipulating the myth of their origins, individual Shinnecock hope to improve their life

Another mythical belief shoring up the notion of tribal society is the idea that tribes reproduce among themselves. A great deal of research in human genetics has recently been undertaken with this specific premise in mind. One of the most ambitious of such projects is led by geneticist James V. Neel and draws on the substantial ethnographic talents of Napoleon Chagnon, whose field work among the Yanomamö Indians of southeastern Venezuela and adjacent Brazil has given focus to the Neel team's research.

Central to the project is the concept of tribe. Neel and his colleagues describe their work, in their own words, as "an effort to characterize in all ways possible the genetic parameters of a relatively large and undisturbed tribe."

An essential element in their conception of tribe is relative physical isolation, which results in a high degree of breeding isolation. This conception requires that the Neel team differentiate tribes within actually continuous populations. Members of the project have described the Yanomamö and the Makaritere, an adjacent people, as clearly defined and separate populations, hostile to each other along their entire common perimeters. But individuals in this region do not

seem to regard or refer to themselves except in terms of the village in which they reside.

Furthermore, as we learn from Chagnon's own accounts, there is a long history of common residence in single villages of people identified by the Neel team as either Yanomamö or Makaritere. Long before missionaries or government officials penetrated the jungles inhabited by these people, the Yanomamö and the Makaritere intermarried, apparently oblivious of the tribal differences now stressed by the geneticists. From such situations I am forced to conclude that the conception of tribes as breeding isolates is a gross distortion of actual mating relations.

Just as tribes are not distinct breeding populations, so too they are not clear-cut linguistic communities. Despite this, many anthropologists rank the speaking of a common language above all other criteria of tribal identity. It is difficult to square such an assertion with the fact that some populations regarded as a single tribe speak two or more languages. This is the case on the Brazil-Colombia border, where anthropologist Arthur Sorensen did linguistic and ethnographic field work in Indian villages in which four different languages were ordinarily spoken. Indeed, in such villages it is commonplace for husbands and wives to speak different and often mutually unintelligible languages. To be sure, one particular language, Tucano, is the lingua franca, but that does not make these people Tucanos.

After long consideration of the previous arguments, and a great deal more. I came, reluctantly at first, then more determinedly, to the conclusion that there were no tribes until they were created as a product or by-product of the evolution of the state.

There are numerous theories about the origin of the state. Most theorists who have addressed the point agree that it was formed with relative suddenness through intensification of techniques of domestication of the food supply. Changes in food production led to changes in conditions of labor demand, thereby ushering in a demographic shift



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as well. The ensuing population growth promoted various kinds of social heterogeneity, none more important than differential access to basic resources among different members of the same society: the defining condition of social stratification.

Stratification means that society is divided into haves and have-nots, a condition of inherent conflict. An apparatus of organized government then emerged to contain and deal with such internal conflict. That apparatus was the state. In attempting to resolve the contradictions into which they were born, most states began a process of physical ex-pansion. The nascent state then turned to its hinterland and began to transform the societies it encountered there into parts of itself or partial replicas or at least organized it into something that could feed some of its needs.

In the New World such a process began, originally, a few thousand years ago with the rise of early civilizations that were ultimately replaced by the Inca, Maya, and Aztec states. The arrival of European colonists on the eastern shores of North America, and their steady press westward, produced the same result—the birth of tribes.

Tribes were manufactured either by the direct political involvement of agents of particular states in the affairs of simpler societies or they were formed as a consequence of indirect pressures, often unconsciously exerted. The latter might be exemplified by a long chain of economic stimuli, set off many years before in a place far removed from the area in which tribes were to be formed. In just this way the demand for beaver skins and other pelts in Europe was ultimately responsible for transforming the society of the native population of northeastern North America. Creating new economic values, trade routes, markets, and media of exchange, the still-distant state forced new regional arrangements of land tenure and resource allocation. Thus began a chain of organizational changes leading to the appearance of formally structured tribes.

Another artifice that contributed to the formation of tribes

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In 1782, by act of Congress, the bald eagle became our national symbol. In those days, the great-bird was commonplace near water since fish constitutes half to four-fifths of its diet. Now, ironically, the very food the eagle depends upon for survival is killing him. DDT and other pesticides accumulate in the bodies of fish and the eagle is unable to produce viable eggs. Although it is now protected by federal law, the eagle is still the victim of trophy hunters. The once limitless king of the skies now finds refuge in wildlife sanctuaries.

The eagle is only one of 114 species and sub-species of wildlife in the United States now threatened with extinction. Foremost among the private non-profit agencies devoted to the protection of these and all forms of wildlife is the National Audubon Society. It maintains 44 sanctuaries throughout the country to provide safe nesting, feeding and resting sites for birds, and a protected environment for other wildlife. Jean Dorst, the great European environmental scientist has said, "The National Audubon Society... has done more to protect nature than any other private group in the world,"

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was the creation of chieftains. Government agents, explorers, traders, missionaries, and soldiers, by initiating and maintaining communication with particular individuals, knowingly or unknowingly created local chiefs where none had previously existed. Sometimes they enhanced the status of such a person-or literally manufactured a new status-by giving him new goods or even a strange and powerful weapon. The agents of the state needed somebody to take orders, to convey messages, to link them with the strange society, even to act as a conduit for siphoning off as much of the surplus as they could drain from these poorly organized populations.

There are many other ways in which the same end has been accomplished. Sometimes it has been military, as states induced native populations to join their wars-witness the history of what we, in the United States, refer to as the French and Indian War. Sometimes it is religious, as missionaries and priests encourage the formation of tribes to facilitate conversion. It can even be carried by those who would escape the state, as anthropologist William S. Willis, Jr., has shown in his analysis of the effects of runaway slaves upon various Indian societies in the colonial American southeast.

The manufacturing of tribes has been under way for more than five thousand years in some parts of the world, but elsewhere it began in the last century or even in this one. So subtle and thorough is the process that it seems to obliterate the past-even our images of the past. People involved in the process become confused. They think they have always lived in tribes, and the people in states, looking at them, think so too. The myth of tribe, however, is not benign but malignant. The myth of the antiquity of the tribe is a shackle not only to those assigned to tribal states but also to those who, directly or indirectly, bear responsibility for the creation of tribes. It is time to dispense with the myth and acknowledge tribes for what they are-products and servants of the state.

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The Limits of Plant Power

Electrical currents flow through the tissues of plants, but what external stimuli do they respond to?

I do not believe that plants respond electrically to human thoughts and emotions or to distant traumatic events happening to other organisms (see "The Unscientific Method," Natural History, March, 1974). But that doesn't mean that I doubt the existence of electrical manifestations in plants. Indeed, this old and respected aspect of plant physiology has always fascinated me. Colleagues working in my laboratory at Yale University have recently done some elegant experiments that link certain plant movements to measurable electrical changes in the tissues. The time seems ripe for new advances in our understanding of plant electrophysiology, so perhaps it is worthwhile to discuss the subject.

The electrical activities of plants are not nearly as large or spectacular as analogous phenomena in animals. The electric eel, for example, can produce several hundred volts with an output of about 100 watts. This is enough to kill a small animal, stun a man, or light a series of bulbs. No plant can do this or anything close to it. The usual plant potentials of about 100 millivolts are more than a thousand-fold less than those of the electric

eel, and plant currents of several microamperes are also quite low when compared with those of animals. Animal response to externally applied current is also much greater than that of plants. Thus, a brief electrical pulse administered to a nerve can cause violent twitching in an attached muscle (witness the famous frog leg experiment of the Italian physiologist Luigi Galvani, performed in the late eighteenth century), while a similar stimulus given to a plant results in a gentle and slow change in the growth rate of the stem or root or possibly in a slow growth curvature in the direction of the positive or negative electrode.

The faster and larger animal responses are undoubtedly due to the presence of nerves, those specialized cells whose entire structure and physiology are geared to the production and conduction of electrical signals. The transfer of any stimulus along a nerve causes electrical changes along the surface of that cell, and "action potentials" (voltage changes in response to an applied stimu-· lus) of ten or more millivolts are readily recorded. Both the propagated impulse and the recorded potential arise because of changes that occur across the membrane of the nerve cell; they, in turn, lead to a flow of local currents along the outside of the nerve.

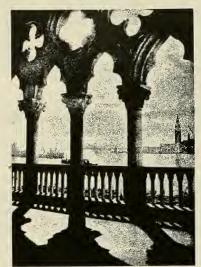
The membrane changes that cause the observed potentials and current flow are connected with movement across the membrane of certain salts, especially of charged ions like sodium and potassium. Outside the human nerve cell, the major ions are positively charged sodium and negatively charged chloride, the two components of ordinary table salt. Inside the nerve cell, sodium is a minor constituent and is largely replaced by potassium, a related element.

The unique permeability characteristics of the nerve membrane permit the separation of these highly mobile salts into two compartments, the inside and the outside of the nerve cell. Potassium is roughly fifty times more concentrated inside the cell, while sodium is more concentrated outside. This unequal distribution of dissolved and freely diffusible ions across the membrane is what produces the observed electrical potential. If, for example, there is a tenfold difference in the external and internal concentrations of a salt, the resultant potential is about sixty millivolts, a value frequently observed in biological systems.

When an impulse is propagated along a nerve, a wave of "depolarization" occurs, meaning the observed potentials will suddenly drop. The drop is due to the opening of pores in the membrane, permitting the free diffusion of sodium into the cell and potassium out of it. This exchange diminishes the gradients for both sodium and potassium, and the diminished potential across the membrane is the re-

sult. During the recovery phase, the operation of "ion pumps" in the membrane restores the original differences in concentration. These pumps, made of protein, utilize metabolic energy to move ions against their natural gradient. This latter process, known as active transport, is common to all

living cells. In plants, fairly large electrical signals are manifested during vigorous movements, such as the folding of the leaflets of a Mimosa ("the sensitive plant") when they are touched or the sudden closing of the Venus flytrap. The folding together of certain leaves during sleep, which results from pressure changes in the motor cells at the base of the leaf stalk, are known to be due to cellular changes in the content of salt, especially of potassium. Recently. plant physiologists Richard Racusen of the University of Vermont and Ruth Satter of my laboratory implanted electrodes into these motor cells and detected electrical potential differences between their dorsal and ventral halves. The observed signals changed in an orderly way during a daily cycle, and the oscillations in potential showed some correlation with both the internal daily rhythm and the light-dark transitions in the outside world. An analysis of the mechanism of the movements exhibited some parallels with nerves, in that depolarization, ion movement through pores, and ion pumps were all involved.



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Carras, 630 Fifth Avenue, New York, N.Y. 10020, (212) 757-0761 The m.v. Daphne, 17,000 gross tons, will sail under the flag of Greece. Many years earlier, biophysicists E. J. Lund at the University of Texas and Harold S. Burr at Yale had shown that electrical fields and gradients could be mapped in almost all organisms. including many plants. Lund demonstrated that the cylindrical leaf sheath of grass seedlings is consistently more electropositive at its tip than at its base. Such longitudinal electrical gradients are correlated with growth patterns. Recently, Ian Newman, an Australian plant physiologist working at Harvard, showed that these gradients are changed when the tissue is exposed to red or far-red light perceived by the plant pigment phytochrome.

When kept erect and in a uniform environment, leaf sheaths. stems, roots, and other cylindrical plant organs normally show no transverse potentials. If the organ is laid on its side or is exposed to unilateral light, however, it quickly develops a transverse electrical potential. In leaf sheaths, the side that becomes electrically positive will grow more rapidly than the other side. The resultant inequality in growth rate leads to the familiar curvature of the leaf sheath toward light and away from the

center of the earth. Plant physiologist A. R. Schrank, working in Lund's laboratory in Texas, demonstrated that both transverse potentials and growth curvatures induced by light or gravity can be prevented by passing about fifty microamperes of direct current through the tissue. This result depends on the orientation of the electrodes, for if their signs are reversed, the current will augment rather than impede the effects of unidirectional light or gravitational field. The obvious implication is that the electrical field induced by light or gravity is central to the curvature response.

All agents that cause the curvature of seedling grass leaf sheaths also cause an unequal lateral distribution of auxin—a plant growth hormone. For many years it was assumed that the various unilateral stimuli worked by first producing the transverse electrical potential. This in turn could cause the auxin to become

asymmetrically distributed, leading ultimately to altered growth rates and curvature. But a few years ago, biophysicists Lennart Grahm and C. H. Hertz, working in Lund. Sweden, proved convincingly that the transverse electrical potential could not develop in the absence of auxin, and that the transverse redistribution of auxin preceded the appearance of the potential.

The mechanism leading to auxin redistribution is still unclear, but it is apparently not a transverse electrical field. The effect of auxin in making possible the appearance of an electrical potential may be related to its recently discovered role in speeding up the activity of a membrane-based hydrogen ion (or proton) pump. Such a pump, like the so-dium-potassium pump of nerves, could have a marked effect on the generation and maintenance of electrical potentials.

Each discovery in the field of plant electrophysiology seems to bring with it new mysteries. For example, it has recently become clear that the cap cells surrounding the root tip are necessary both for response to gravity and for development of the transverse biolectric potentials. In the roots of corn. as shown by a team of botanists at Bedford College. London, the root cap can be gently removed without any effect on the root's rate of growth. Such a decapped root, however. cannot curve in response to gravity, nor can it develop any new surface charges in response to light perception by phytochrome. Yet as soon as regeneration of the root cap occurs. both electrical and curvature responses reappear.

One of the most appealing of the newer experiments in plant electrophysiology has recently been performed by biologist Lionel Jaffe and his colleagues at Purdue University. The eggs of certain brown seaweeds. like Fucus and Pelvetia, are perfectly symmetrical spheres. Shortly after fertilization, they develop an asymmetry-one side, the rhizoidal pole, bulges out to form a tube that ultimately becomes the rootlike rhizoid. This structure develops into the bottom. or holdfast end. of the plant, while the opposite end of the egg goes on to form the flat thallus that we recognize as the characteristic brown rockweed. The appearance of this bipolarity in the spherical egg can be controlled by a variety of factors, including light. Unilaterally illuminated fertilized eggs uniformly form rhizoidal poles on the shaded side.

Jaffe used this effect to investigate the bioelectrical properties of the system. If eggs were lined up in a row in a narrow tube and not subjected to further influences, they developed rhizoids at random, and no measurable electrical potential existed across the two ends of the tube. If, on the other hand, the cells in the tube were first oriented by unilateral light so that they all developed rhizoidal poles in the same direction, the eggs then acted as if they were part of an electrical series and built up measurable electrical potentials across the ends of the tube. The developed potentials correlated well with both the percent of eggs that germinated and the length of their

growing rhizoids. In a parallel experiment. Jaffe placed a layer of polarized eggs on a perforated metal sheet containing pores whose diameters snugly fit the eggs. This assembly of light-polarized eggs acts like a calcium pump: calcium is taken in more rapidly at one end and extruded more rapidly at the other. It therefore appears that the ion pumping and the developed electrical potential are both closely related to the processes leading to the polarization of growth and to the ultimate differentiation of the plant body. Unlike some of the claims of electrical response of plants to psychic human stimuli, these experiments can be readily repeated by independent and disinterested investigators in laboratories all over the world. The findings of Jaffe and others are certain to bring new insights and vigor to the study of plant bioelectrics, and a knowledge of these basic phenomena is a necessary foundation for experiments that purport to demonstrate the response of plants to any external stimulus.

Columnist Arthur W. Galston teaches biology at Yale University.

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Reverend Burnet's Dirty Little Planet

"If there is any consistent enemy of science, it is not religion, but irrationalism"

"We do not seem to inhabit the same world that our first forefathers did. . . . To make one man easie, ten must work and do drudgery. . . . The earth doth not yield us food, but with much labor and industry. . . . The air is often impure or infectious.'

Modern eco-activism this is not. The sentiment is right, but the style is a giveaway. It is, instead, the lament of Rev. Thomas Burnet, author of the most popular geologic work of the seventeenth century-The Sacred Theory of the Earth. His words depict a planet fallen from the original grace of Eden, not a world depleted by too many

greedy men. Burnet's Sacred Theory is surely the most famous, the most maligned, and the most misunderstood among the works of scriptural geology. In it, he tried to provide a geologic rationale for all biblical events, past and future. A common view of the relationship between science and religion holds that the two are natural antagonists and that science has increasingly advanced into intellectual territory formerly occupied by religion. In this simplistic context, Burnet's attempt to uphold the scriptures is a futile finger in a truly crumbling

But the actual relationship between religion and science is complex and varied. Often, religion has actively encouraged science. If there is any consistent enemy of science, it is not religion, but irrationalism. Indeed, Burnet, the divine, fell prey to the same forces that persecuted Scopes, the science teacher, almost three centuries later in Tennessee. By examining Burnet's case in a time and a world so different from our own, we may gain a broader understanding of the persistent forces arrayed against science.

I will begin by sketching Burnet's theory. From our point of view, his theory will appear so silly and contrived that a role for Burnet among dogmatic antiscientists will seem almost inescapable. But I will then examine his methods of inquiry, which place him among the scientific rationalists of his time. In noting his persecution by dogmatic theology, we merely watch the Huxley-Wilberforce debate or the creation controversy of California played again by the same actors

in different garb.

Burnet began his inquiry to discover where the waters of Noah's flood came from. He, like others of his time, was convinced that the current oceans could not drown the earth's mountains. "I can as soon believe," wrote a contemporary, "that a man could be drowned in his own spittle as that the world should be deluged by the water in it." Burnet rejected the idea that Noah's flood might have been a merely local event, falsely extended by witnesses who could not have traveled widely-for that would contravene the authority of sacred scripture. But he rejected even more strongly the notion that God had simply created the extra water as a miracle-for that would dispute the rational world of science. He was led, instead, to the following account of earth history.

From the chaos of the primeval void, our earth precipitated as a perfectly ordered sphere. Its materials sorted themselves according to their densities. Heavy rocks and metals formed a spherical core at the center with a liquid layer above and a sphere of volatiles above the liquid. The volatile layer consisted mostly of air, but it also included terrestrial particles. These precipitated in time to form a perfectly smooth, featureless earth atop the liquid

In this smooth Earth were the first scenes of the world, and the first generation of Mankind; it had the Beauty of Youth and blooming Nature, fresh and fruitful, and not a Wrinkle, Scar or Fracture in all its body; no Rocks nor Mountains, no hollow Caves, nor gaping Channels, but even and uniform all over.

There were no seasons amidst this original perfection, for the earth's axis stood bolt upright and the Garden of Eden, conveniently situated in a middle latitude, enjoyed a perpetual spring.

But the earth's own evolution required the destruction of this earthly paradise, and it happened naturally just when disobedient mankind required punishment. Rainfall was light, and the earth began to dry up and crack. The sun's heat vaporized some of the water below the surface. It rose through the cracks, clouds formed, and the rains began. But even forty days and nights could not supply enough water, and more had to rise from the abyss. The falling rain sealed the cracks, forming a pressure cooker without a relief valve as the vaporizing water below pushed upward. The pressure built, and the surface finally burst, causing floods, tidal waves, and the rupture and displacement of the earth's original surface to form mountains and ocean basins. So violent were these disruptions that the earth was wrenched to its current axial tilt (vide Velikovsky). The waters finally retreated to the abyssal caverns, leaving "a gigantic and hideous ruin . . . a broken and confused heap of bodies." Man, alas, had been made for Eden, and the patriarchal life-span of circa 900

years declined more than tenfold.

And so, according to Reverend Burnet, we inhabitants of a "dirty little planet" await its transformation as promised by scripture and reasoned from planetary physics. The earth's volcanoes will erupt all at once, and the universal conflagration will begin. Protestant Britain, with its reserves of coal (then largely unmined) will burn with a fury, but the fire will surely start in Rome, the papist home of antichrist. The charred particles will precipitate slowly back to earth, forming once again a perfect sphere without relief. And so the 1,000-year reign of Christ will commence. At its end, the giants Gog and Magog will appear, forcing a new battle between good and evil. The saints will ascend to the bosom of Abraham, and the earth, having run its course, will become a star.

Utterly fantastic? Sure, for 1975; but not for 1681. In fact. for his own time, Burnet was a rationalist, upholding the primacy of Newton's world in an age of faith. For Burnet's primary concern was to render earth history not by miracles or divine caprice, but by natural, physical processes. Burnet's tale may be fanciful, but his actors are the ordinary physical forces of desiccation, evaporation, precipitation, and combus-tion. To be sure, he believed that the facts of earth history were given unambiguously in scripture, yet they must be consistent with science, lest God's words be opposed to his works. Reason and revelation are two infallible guides to truth, but

'tis a dangerous thing to ingage the authority of Scripture in disputes about the Natural World, in opposition to Reason; lest Time, which brings all things to light, should discover that to be evidently false which we had made Scripture to assert.



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Moreover, Burnet's God is not the continuous and miraculous actor of a prescientific age, but Newton's imperial clockwinder who, having created matter and ordained its laws, let nature run its own course:

We think him a better Artist that makes a Clock that strikes regularly at every hour from the Springs and Wheels which he puts in the work, than he that hath so made his Clock that he must put his finger to it every hour to make it strike; And if one should contrive a piece of Clock-work so that it should beat all the hours and make all its motions regularly for such a time, and that time being come, upon a signal given, or a Spring toucht, it should of its own accord fall all to pieces; would not this be look'd upon as a piece of greater Art, than if the Workman came to that time prefixt, and with a great Hammer beat it into pieces?

I do not, of course, argue that Burnet was a scientist in any modern sense of the term. He performed no experiments and he made no observations of rocks and fossils (although several of his contemporaries did). He used a method of "pure" (we would say armchair) reason, and he wrote with as much confidence about an unobservable future as about a verifiable past. Likewise, his procedure is followed by no modern scientist that I know, with the exception of Immanuel Velikovsky (see last month's column)-for Burnet assumed the truth of scripture and fashioned a physical mechanism to make it happen, just as Velikovsky invented a new planetary physics to preserve the literal account of ancient records.

Yet Burnet was no pillar of the theistic establishment. In fact, he got himself into considerable trouble over the sacred theory. In the best tones of the Inquisition, the bishop of Hereford attacked Burnet's reliance on reason: "Either his Brain is crakt with overlove of his own Invention, or his Heart is rotten with some evil design"—that is, the subversion of the church. In a classic statement of antiscience, another clerical

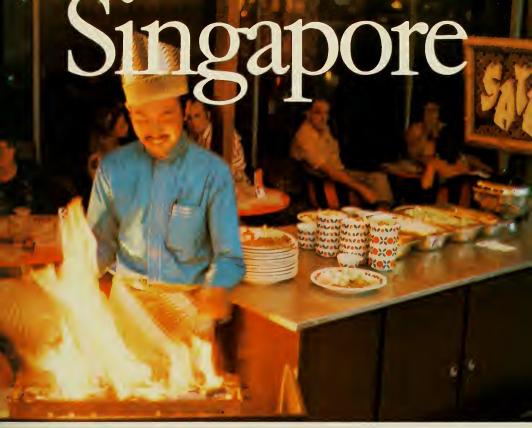
critic remarked: "Though we have Moses, yet I believe we must stay [wait] for Elias, to make out to us, the true Philosophical modus of the Creation and Deluge." (The biblical reference is to Elijah, who will return to herald the Messiah's adventthat is, science cannot discuss these questions and we must await some future revelation for their solution.) John Keill, an Oxford mathematician, argued that Burnet's natural explanations were dangerous because they encouraged a belief that God is superfluous.

Nonetheless, Burnet prospered for a time. He became Clerk of the Closet at the court of William III. (That title is not a fancy name for latrine cleaners but a designation for the royal confessor-the closet being a chapel for the king's private devotions.) Rumor has it that he was even considered as a possible successor to the Archbishop of Canterbury. But Burnet finally went too far. In 1692, he published a work advocating an allegorical interpretation of the six days of Genesis-and he promptly lost his job, despite his profuse apologies for any unintended offense.

It was the dogmatists and antirationalists who got Burnet in the end, not the theists (there were no reputable atheists outside the closet in seventeenth-century England). One hundred years later, the same men made Buffon retract his theory of the earth's antiquity. One hundred fifty years after that, they unleashed a pompous, three-time loser against John Scopes. Today, using the liberal rhetoric of equal time, they are trying to drive evolutionary theory from the nation's textbooks.

Science, to be sure, has transgressed as well. We have persecuted dissenters, resorted to catechism, and tried to extend our authority to a moral sphere where it has no force. Yet without a commitment to science and rationality in its proper domain, there can be no solution to the problems that engulf us. Still, the Yahoos never rest.

Stephen Jay Gould teaches geology at Harvard University.



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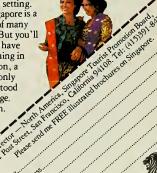
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Oaxaca's Spiraling Race for Water

When new crops and technology came to a Mexican community, old balances and traditions gave way

In the hot sunlight of the Valley of Oaxaca, in Mexico's southern highlands, a Zapotec farmer peers into the hand-dug well in the center of his small plot of land. For several hours he has drawn up buckets of water and poured them over his pepper plants; now the well is dry, and he will have to wait until tomorrow to tend the last few rows-if they survive another day of desiccation in the heat.

Shading his eyes with his hand, the farmer looks across his plot to the fields of a neighbor who has drilled a deep well and bought a diesel-powered pump. Water flows wastefully in the furrows between his plants. The mechanized pump saves labor, but it lowers the water table more quickly, so that all the shallow wells in the area run dry within a few hours.

Hand irrigation of crops is a

3,000-year-old tradition in the Valley of Oaxaca. This ancient method indirectly regulated the use of water and maintained a long-term balance between farmers and their resources. But new

Farmers have traditionally grown vast fields of flowers in the southern arm of the Valley of Oaxaca. They are shipped throughout the year to Mexico City in refrigerated trucks.

photographs by Mellon Tytell





Reservoirs constructed by the government now supply water to some crops grown on the piedmont.

These reservoirs, however, lower the water table on the valley floor.

irrigation practices, which have yet to come under general social or legal controls, require a new kind of response, a different social order.

For nearly 10,000 years there has been continuous occupation in the Valley of Oaxaca. The archeological sites at Monte Albán and Mitla are spectacular evidence of Oaxaca's leading role in the rise of Mesoamerica's ancient civilization. Based on a highly productive agricultural system, the civilization that created these monuments owed its success to the fertility of the valley's alluvial plain, the diversity of its environmental subzones, and the variety of techniques that were used to exploit them.

Water was then, and still is, the Oaxacan farmers' single most critical resource. Rainfall averages twenty to thirty inches each year, most of it coming during June, July, and August. But from one year to the next, the amount of rain and where it falls is unpredictable. In some parts of the valley the evaporation rate is four times the rate of precipitation, and farmers must use a variety of irrigation methods, depending on the local topography, to increase the water supply and meet the needs of their crops.

The Valley of Oaxaca is a region of contrasts. Steep, cool, and densely forested mountains surround the sixty-mile-long valley. But the narrow piedmont leading to the valley floor is barren and rocky, coming to life only in summer. For the most part, this zone is suitable only for growing maguey, a cactus from which alcoholic beverages and rope fibers are produced. Within this arid

band, however, springs and streams, flowing throughout the year, support lush vegetation on their banks.

The Atoyac River, which divides the length of the valley floor, is joined by its main tributary, the Salado River, at the center of the valley. The two rivers give the valley the shape of a giant Y, with arms to the northeast, south, and southeast. Here, along the warm, wet valley floor, the rich alluvial soils grow a variety of crops during most of the year.

Farmers in this part of the valley have traditionally excavated tento twenty-foot-deep wells in their fields, from which they have drawn water by hand. Requiring intensive labor, this type of irrigation has been restricted to less than 10 percent of the cultivated land. But as a means of providing cash crops, such as green peppers and garlic, it still has considerable economic importance. Farmers can grow up to three crops each year using this technique.

In piedmont areas far from springs and streams, farmers use floodwater from rainfall for irrigation. After a heavy rainstorm, simple stone and brush dams block the water running off the mountains and down the piedmont slopes so that it flows more gently over the fields, briefly covering them. This is a difficult and unreliable undertaking; a strong current could sweep away the dams or uproot the plants. After each storm a farmer must carefully control the flow of water to his fields so that his crops get enough water but not too much: overflooding will kill them.

Farmers who cultivate near piedmont streams are more fortunate because their water supply lasts longer and is not as unpredictable. Placed at strategic points along a stream bed, brush, concrete, and stone dams—similar to those used for floodwater irrigation—channel the water through earthen canals to the fields. Where the ground is uneven, wood and stone aqueducts smooth out the canal bed.

The techniques of the canal system are quite simple, and farmers in the Valley of Oaxaca have been using them since 300 B.C. Their use can double or even quadruple crop yield, as they not only increase the water supply to the plants but also extend the growing season, permitting two crops to be planted in one year: one crop dependent partly on rainfall; the other, exclusively on canal irrigation.

Like their ancestors, Zapotec farmers today rely for subsistence primarily on corn, beans, and squash-plants well adapted to this arid climate. Although corn is the major crop in the valley, grown on 30 to 70 percent of the arable land, a certain proportion of the land has always been devoted to small-scale, cash-crop production for sale at weekly regional markets. In the northeastern arm of the valley, fruit and wheat were important cash crops. Flowers and vegetables remain important cash crops in the central and southern areas of the valley, while the drier southeastern arm continues to specialize in maguey production.

The problem of seasonal water scarcity has been aggravated by the introduction of new cash crops,

On the valley floor, most crops are grown on one-acre plots. Until diesel pumps were introduced, farmers irrigated plants by hand from shallow wells scattered over the fields.

particularly alfalfa. With the recent growth of an urban market for milk products, farmers in the northern and central regions of the valley have found dairy farming a profitable source of income. To get the maximum amount of milk from their cows, dairy farmers prefer to stall feed their animals fresh alfalfa. This crop, now grown extensively for farm use and sale throughout the valley, has become Oaxaca's major irrigated cash crop. In some villages in the northern and central regions of the valley, nearly half the cultivated land is devoted to alfalfa.

Alfalfa may be profitable, but it requires a great deal of water: the more it is irrigated, the more it grows. Producing continuously for five to ten years, it needs water throughout the year. In the piedmont, alfalfa places heavy demands on stream water for canal irrigation; on the valley floor, farmers have installed diesel pumps in their wells to tap the water table with greater intensity than traditional techniques

Unprecedented demands are now being made on the valley's water resources. Nine-foot-deep wells in the alluvium, which are still tapped by hand, dry up after two to four hours of use per day. Pump-drawn wells generally tap water at deeper levels-twelve to forty feet deep-but the increasing scarcity of water at these levels is now forcing some farmers to dig wells as deep as 90 to 180 feet. This usually requires government technical and financial assistance since villagers cannot carry out such a project using traditional methods.

In the upper piedmont zone,

villages, assisted by government agencies, have built concrete dams and reservoirs in order to more efficiently tap stream waters and guarantee adequate year-round supplies for both irrigation and domestic use. But the intensive use of this water decreases the amount available in lower piedmont and alluvial villages, which formerly received a sufficient amount. These lower villages rely increasingly on deeper wells and more powerful pumps.

Even on the valley floor, where the water table is the highest, intensive pumping at higher altitudes makes hand-drawn water unreliable, and farmers turn, as much through necessity as through choice, to newer, more expensive technology. At the same time, they reduce the availability of their essential resource—water.

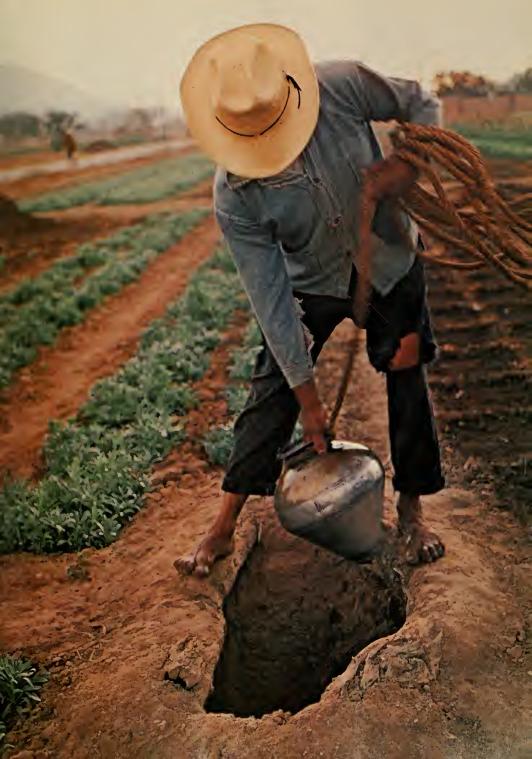
Not only does alfalfa use a great deal of water but the method used to irrigate this crop is more wasteful, given the high evaportation rate, than the traditional hand-drawn technique. More water evaporates when it is spread on fields in furrows than when it is placed by hand only on the plants, not on the areas beside them. Storage dams, with extensive open water surfaces, also entail high water loss through evaporation. As a result, water shortages keep appearing despite investments in new irrigation technology.

Because of their shift to alfalfa, Oaxacan farmers depend more and more on technical assistance from the federal government, which frequently aids in the construction of new reservoirs and deep wells. As the farmers' dependence on technology grows, their interest and participation in national political institutions increases and their traditional isolation from the outside world rapidly disintegrates.

Government technicians who come to a rural community to help modernize irrigation facilities also attempt to modernize the organization of the village's water administration. Traditionally, the use and maintenance of community canals and wells varied from village to village according to local custom. Now, communities must alter their customs to conform to government standards and elect water committees responsible to the governmental agency that helped to construct the irrigation device. The government has also intervened in the allocation of water for urbanization and industry. Communities have thus lost control over their own resources.

Along with a change in the relationship of rural communities to the outside world has come a shift in attitudes and values within the community. Until ten or fifteen years ago, the accumulation of material wealth received little emphasis. Prestige and respect could be attained only by fulfilling community obligations. Among the most important of these was the personal sponsorship of a fiesta in celebration of one of the saints whose image was kept in the village church.

The member of the community sponsoring such a celebration had to buy fireworks, food, liquor, and the services of musicians, which sometimes required years of advance planning and saving. To raise money to pay for a fi-









Radishes are a cash crop new to the valley. Other cash crop vegetables are green peppers, beans, and tomatoes.

esta, the sponsor was expected to use not only the profits from his good harvests but also to borrow goods and money from his friends and neighbors. Such loans would be repaid at a later date, perhaps when the lenders sponsored their own fiestas.

The continual flow of small surpluses within communities and the frequent borrowing and lending helped to mitigate the risks of crop failure in this uncertain environment. A farmer who had suffered a poor harvest always had some people in debt to him. And those who helped him did so with the realization that some day they, too, would have to seek

help from a neighbor.

With this system of borrowing, lending, and ceremonial expenditure, there was little left over to invest in agricultural improvements, such as new equipment or chemical fertilizers. Partially because of this system, farmers did not attempt to produce the largest possible crops every year. Realizing that part of their profits would be drained away through loans and debt repayment, farmers geared production toward their own immediate but limited needs.

They adjusted the amount of land and seed they planted to the amount of rainfall they expected, basing their estimate on the spring rains. In years expected to be very dry, they planted more; in those expected to be wetter, they planted less. As a result, over the long run production remained fairly low and did not strain the environmental resources.

This traditional system depended for continuity on yet another factor: the isolation and relative autonomy of the local communities from the national governmental and economic institutions. Historically left to themselves, rural communities in an unpredictably varying environment devised social systems that spread the costs of community government and the risks of poverty. The result of this isolation and self-sufficiency was minimal participation in national and world markets, minimal aid on the part of the national government in developing agriculture, low production levels, and a low standard of living for Oaxacan farmers.

The days of isolation have now ended. Federal and state governments, with some community support, are pressing for change. Increased schooling affects every household. Better transportation methods bring new products to the valley and make easier the exportation of crops to urban markets. Cities have increased the demand for agricultural products, and technology offers the means of providing them.

In traditional communities the individual's sole path to prestige lay in ceremonial sponsorship, but new cash crops, markets, and technological inventions are providing other alternatives. Today young Oaxacan farmers look to increased crop yields as a means of raising their standard of living and, hence, their social status according to values outside the local community.

Once farmers begin to base their prestige on material achievements, they intensify their use of local resources, particularly water. While traditional farmers decreased their acreage in good years because they could satisfy their needs with limited effort, the goal of today's farmers is not just to satisfy their needs but to maximize their profits. In the effort to fulfill these new goals, farmers avoid—and then abandon—the former ideals of community and religious obligation.

When traditional values are undermined, community institutions lose their effectiveness in maintaining ecological equilibrium. Traditional farming, with its limited use of subsurface water, precluded overuse and, hence, scarcity of a vital resource. But now many farmers use all the water they have and thus contribute to conditions of scarcity for all.

In accepting the goals and the technology of the modernized world that surrounds them, Oaxacan farmers are burning their bridges behind them. They cannot reap the benefits of their new markets and cash crops without increasing their exploitation of ground and stream water. As they do so, the agricultural process becomes increasingly costly, in terms of both resources and technology. To pay for continued provision of water, as well as new technology, they are obliged to become increasingly dependent on the outside world. More and more, farmers must abandon their community traditions-traditions that for centuries had maintained a balance between them and their environment. Once the ancient balance is lost, they will have little choice other than to continue to change as they move rapidly toward an uncertain future.

Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun is still in Pisces at mid-April, moves into Aries shortly after, and continues in Aries until mid-May, when it moves into Taurus. In so doing, the sun increases its distance north of the Equator from about 10 degrees in mid-April to nearly 19 degrees by mid-May.

The waxing crescent moon is in the evening sky at mid-April, becoming the first-quarter moon on April 18. It continues to light the early evening sky as the waxing gibbous moon until it is full on April 25. Last-quarter moon is on May 3; new moon on May 11; and the early crescent returns to the evening sky about May 14.

Stars and Planets This month's star map shows Saturn in the constellation Gemini, to the right (east) of Pollux and Castor, the constellation's brightest stars. Saturn appears in the southwest after sundown. Venus is also a prominent evening star, quite bright in the west from early evening twilight until it sets (too early to appear on our map).

Mars is the most readily seen planet in the morning sky, rising a few hours after midnight, well up in the southeast by dawn. The planet is brighter than any of the nearby stars in Aquarius and Pisces. Jupiter begins its cycle as a morning star this month. You may see it low in the east in late twilight by mid-April; by mid-May it is higher and easier to see an hour or so before sunrise.

April 17: Look for Saturn near the moon tonight, well up in the southwest. The moon separates slowly to the east (left) as both move toward the western horizon, where they set before midnight.

April 18: Mercury is in the same direction as the sun today, but beyond it (superior conjunction). The planet, moving from right to left past the sun, enters the evening sky.

April 22: Venus, this evening, is above and to the right of Aldebaran, the bright red star in Taurus. On successive evenings, Venus moves to the left and away from the star.

April 23: The moon is at perigee, nearest earth.

April 24: The moon tonight is near Spica, the brightest star in Virgo, passing very close to it about 9:00 P.M., EST, moving to the left (east) of the star afterward.

May 5: The moon is at apogee, farthest from earth.

May 6: The bright object below the crescent moon in the morning sky is Mars.

May 8: Look below and to the right of the crescent moon this morning, and you may see Jupiter, rising as a morning star.

May 11: A partial solar eclipse occurs today, visible throughout Europe, North Africa, and northern Asia. The eclipse is also visible from the extreme northern regions of North America from Hudson Bay westward.

May 14: Venus is near the moon early this evening.

May 15: Saturn is nearer to the moon tonight, to its right; Venus is farther to the right and lower.

★ Hold the star map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:25 P.M. on April 15; 9:25 P.M. on April 30; and 8:25 P.M. on May 15; but it can also be used for about an hour before and after these times.







A Year in the Life of a Harp Seal

Text and photographs by Fred Bruemmer

The perilous path from nursery to sea haven is marked by crushing ice floes and the deadly clubs of sealers

East of southern Labrador lie thousands of square miles of floating pack ice, its drift determined by the steady, relentless force of the Labrador Current and by fierce winds. Compacted by awesome easterly gales, raftering ice floes are pushed above and below each other. Shattered floes, some three feet thick, rear up to form jagged pressure ridges.

Yet in this apparently desolate landscape there is life: dark spindle shapes upon the white floes—as many as 5,000 to each square mile of ice. This hostile environment is a nursery of the harp seal (Pagophilus groenlan-

dicus), whose life cycle and vast annual migrations move in rhythm with the formation and disintegration of the immense northern ice fields.

In early March, at the beginning of the pupping season, the adult seals are swathed in fat. The blubber, up to 2½ inches thick and constituting more than a third of a seal's total weight of 250 to 300 pounds, serves both as insulation and metabolic fuel.

A harp seal can lie for hours upon the ice, yet leave barely a trace: while its skin temperature is only slightly above the freezing point, its internal temperature is a cozy 99.2° F. Restricted peripheral circulation allows just enough blood to reach the skin to keep it healthy. Because heat dissipation is kept to a minimum, an increase in the metabolic rate is not necessary to generate heat, whether the seals lie on the ice or

are enveloped by the sapping chill of arctic and subarctic water.

Big-headed, spindly-bodied newborn pups lie on the ice by the tens of thousands, their nearly two-inch-long coats of curly white wool stained yellow by amniotic fluid. The pups now face a perilous period in their lives. They must survive not only the dangerous, crushing movements of the ice on which they were born but also the heavy hand of sealers who treasure their natal skins.

Almost immediately after giving birth, the female nuzzles and licks her pup, and soon the pup begins to cry—a tremulous, highpitched, persistent lamblike bleat. In the first few minutes after birth, the specific scent and sound of her pup are probably imprinted upon the mother, who can thereafter distinguish it from



the tens of thousands of others born on the floes of the whelping patch. After she spends time in the sea, a female hauls out and searches for her pup-often guided by its cries-in the general location where she left it. An identifying nuzzle completes recognition.

The pup, on the other hand, seems incapable of identifying its mother; "mother," normally, is the big, dark form near it. When the mother is away and the pup is hungry, it crawls toward any nearby female. A pup entering a strange female's territory will be warned away with a high-pitched, gurgling snarl. The female may even adopt the threat posture of vertically raised head and neck, which she usually assumes only when another female comes too near. If the pup ignores these danger signals, the female may rush up and cuff it with flailing front flippers so that the pup tumbles, squalling, over the ice.

During the first day or two of its life, the pup, its wooly fur still moist and matted with fetal fluids, is protected against temperatures as low as -15° F. only by its fur and a blubber layer that is usually less than one-quarter inch thick. A newborn pup is voracious and begins to suckle randomly along the chest and belly of its six-foot-long mother. The female frequently will use her flippers to shoo the pup toward her lower abdomen where the two teats are located. After an often prolonged search, the pup finds the retracted nipples.

A female harp seal's milk is creamy, yellowish, and viscous and contains 42.6 percent fat and 10.4 percent protein. (Cow's milk contains 3.4 percent fat and 3.3 percent protein.) The pups nurse frequently and, on this rich diet,

balloon out rapidly. Weighing an average of 18 pounds at birth, they triple, and occasionally nearly quadruple, their weight by the end of two weeks, after which they are weaned. This intensivefeeding, quick-growth pattern is ideally suited to the ephemeral nature of the harp seals' birthplace. About 93 percent of this weight gain is in the form of blubber, which grows beneath the pups' skin to two and, in exceptional cases, three inches thick. At the age of two weeks, some pups are so obese that their short front flippers barely reach the ice.

In the following weeks the female parent undergoes just the opposite kind of transformation. After the strain and turmoil of giving birth, courting, and then mating in March, and the considerable stress of molting in April, combined with a fast during much of this time, the female's

Breeding Areas and Migratory Routes of the Harp Seal



cloak of blubber is severely depleted by May. In some females it is only slightly more than half an inch thick, and its total weight has decreased from 125 pounds in March to less than 60 pounds in May.

The "whitecoats," as very young pups are commonly called, begin to molt their natal wool, or lanugo, when they are about ten days old. In roughly four more days they are weaned, and their mothers leave them. The pups, after a period of searching for the suddenly vanished parent, lie plump and placid upon the ice, shedding wool, first from flippers and head, then from the back and belly, and finally from the flanks. Newfoundland sealers call them "ragged jackets" at this stage.

After two weeks of living off their accumulated fat and drifting on the ice floes wherever currents and winds take them, the pups, now in dark gray coats of short, stiff-haired fur, enter the sea and begin to feed on pelagic crustaceans. They swim northward, following the adults (who have since mated, usually in the water but occasionally on the ice) and the immature seals, one to five years old, who are on their way to other ice fields where they will

molt before their arctic migration in May.

Less sociable than the adults and immatures, the four-week-old pups usually swim singly: a widely scattered herd feeding on an abundance of such small pelagic crustaceans as euphausiids, mysids, and amphipods, which occasionally occur in shoals so dense they discolor patches of the northern seas.

Summer is the harp seals' time of ease and relative safety. Seal hunting, once of vital importance to the people of central and southern Greenland, has decreased steadily in the Danish territory over the past few decades. The seals reach western Greenland in June and scatter along the food-rich, fjord-serrated coast as far north as the Thule district.

As the ice breaks up in July and August, some of the vast herds of seals move west into the straits and bays of the Canadian Arctic archipelago. Others spend the summer along the deeply indented coast of southern Baffin Island, and a relatively small number swim into northern Hudson Bay. Thus, although their numbers are immense, the seals are scattered over a sea area of more than a million square miles,

and competition for food is relatively slight in any one region.

These seals form what is known as the Newfoundland herd—one of the three distinct harp seal populations that inhabit different areas of the northern seas. The others are the White Sea (or East Ice) herd, which breeds in late February to early March on the ice of Russia's White Sea, and the Jan Mayen (or West Ice) herd, which produces pups in the middle of March on the ice of the Greenland Sea, in the vicinity of the small island of Jan Mayen.

The Newfoundland herd was and still is the largest of the three harp seal populations. This herd consists of two groups: the "Gulf herd," now numbering about 300,000, which breeds on the ice in the Gulf of Saint Lawrence, usually in the vicinity of the Magdalen Islands; and the "Front herd," reduced by sealers and numbering about 700,000 (compared to 21/2 million in the 1940s), which breeds on the drifting pack ice to the east of southern Labrador and northern Newfoundland.

In September, the ice begins to form again in the far north, and the Newfoundland herd begins the southward part of its annual 6,000-mile migration. It is a slowpaced journey through fish- and crustacean-rich waters. About the middle of October, the first seals reach Cape Chidley, the northernmost tip of eastern Labrador, and by early December they arrive near the Strait of Belle Isle, separating southern Labrador from Newfoundland. Here the migration divides into two branches. About a third of the seals swim through the Strait of Belle Isle into the Gulf of Saint Lawrence. The others, the seals of the Front herd, continue south, to feed in the vicinity of the Grand Banks during the early winter months.

In mid-February, pregnant females are again in search of suitable breeding ice. Many of them are younger than in former years. Studies carried out by David Sergeant, of the Fisheries Research Board of Canada, show that with population decline, the female seals' age of sexual maturity has declined as well. Females normally attain sexual maturity at the age of six years (eight years for males). In the more heavily exploited groups, the females' age of sexual maturity dropped in slightly more than one decade (1952 to 1963) from six to five years for the Gulf herd, to four

years for the Front herd, and to three or four years for the White Sea herd.

On the Front in winter, there is never any lack of ice. Like a vast, watery conveyor belt, currents carry a never-ending supply of ice down from the Arctic Ocean through Davis Strait, which separates Greenland and Baffin Island. The females prefer to pup far from the edge of the

A female sniffs a pup, top, to determine if it is hers. The pup's distinctive odor, along with its location and call, makes identification possible. Because its mother's milk is rich in fat and protein, a nursing pup, below, triples its weight in as little as three weeks.





A mother seal assumes a threat A mother seal assumes a three posture when a strange pup wanders into the territory she is sharing with her offspring. If the pup does not leave, the adult may cuff it away with a flipper.



floating pack, away from waves and storms that are likely to threaten their pups. They swim beneath the ice (harp seals normally come up to breathe every five to ten minutes, but can dive for at least twenty minutes), surfacing in open pools between the floes or in the weak "slob" ice created by the grinding of floes against each other. The female seals enlarge holes in this weak ice with their powerful, longclawed front flippers and, unless open water between floes is nearby, keep these hauling holes open during the entire breeding season.

The Front ice pack is a precarious cradle. Its floes are small, rarely more than 200 feet across, but the ice is usually thick. Twisting with the current, the floes turn and churn and grind against each other. They heave as high as five feet when a heavy swell from the open sea runs through the ice pack; when easterly storms compact the floes, they crack, slip over each other, or rear up into chaotic pressure ridges.

During storms, the females dive into their hauling holes to escape the buckling, crashing floes. They reappear when there are moments of relative calm, haul out and hump over the ice to their pups, then flee again as the ice shudders and groans. In a violent gale, the females dive into the saving sea, where a few are killed by the monstrous mass of shifting ice. But the pups, helpless on the floes, are often killed by the thousands by overriding floes and tumbling ice blocks during winter storms.

The ice is very different in the Gulf of Saint Lawrence. It forms in place and floes tend to be large and flat (sometimes as much as a mile or two across).

Surfacing at the edge of the birth, a female searches for her pup amid thousands in a typical harp seal nursery.

ice floe where she recently gave

The females can easily break hauling holes through weak spots in the ice early in the breeding season while it is still thin. On the other hand, the Gulf ice is rarely as strong as the ice on the Front, and in some years (the last two were in 1953 and 1969) no suitable ice for breeding forms in the Gulf. Then the females. who seem to be able to delay birth by as much as a week, search for any ice. In 1953, they whelped on fragmented, or brash, ice pressed against the north shore of the Magdalen Islands; in 1969, on thin, landfast ice northwest of Prince Edward Island. A southwesterly gale in 1969 broke this ice loose from the land and fragmented it; nearly all the pups born on it are believed to have perished.

Such periodic high losses caused by natural phenomena are very much a part of the ecology of this species. The various harp seal herds have the reproductive capacity to replenish their depleted numbers after weather and ice-related disasters. A few years of good ice conditions during the whelping season, and plentiful supplies of fish and crustaceans along their northward migration routes while they are in a weakened, emaciated condition, and the harp seal populations can rise dramatically.

The harp seal, however, has suffered a very large reduction in numbers during recent times because man has subjected this animal to the greatest, most protracted mass slaughter ever inflicted upon any wild mammal species. Since 1800, counting the additional kill by whalers (a profitable sideline; in 1889, for example, whalers took 300,000 seals on the Front), the millions of molting seals shot but not retrieved, the pelts lost on wind-dispersed floes, and the pelts lost on the more than 500 ships that sank with their sealskin cargoes, an astonishing total of between 48 and 60 million seals have been killed in the Newfoundland herd alone. (These figures include a small percentage of hooded seals.)

The exploitation of the New-

foundland herd began on a large scale in about 1800 and soared to a peak in 1831 when sealing ships returned with 680,000 pelts. During the entire nineteenth century the average annual kill was about 350,000; during this century, about 200,000. (In 1934, a Newfoundland sealing captain, Abram Kean, brought in his one millionth seal, which earned him the Order of the British Empire.)

Sealing was a great industry. In the nineteenth century as many as 400 Newfoundland ships with 13,000 men took part in the annual hunt on the Front. The ships were dark, dank, crowded, and filthy; the food, vile; the pay, poor (about \$50 for a sixweek trip); the work, exceedingly hard and dangerous. Thousands of sealers died (255 in 1914 alone), and thousands more were maimed. But the hunt exerted on the men a strangely powerful, primeval allure, composed of shared adventure and danger and thrill in the kill.

The American author George Allan England, who sailed on a sealing ship to the Front in 1922, wrote perceptively: "Not for mere gain do men endure such miseries as the hunt entails . . . it is their annual carnival . . . of bloodshed." England was horrified by the hunt's cruelty: "Some of the seals, appallingly vital creatures, are not at all dead as they are hauled in on gaffs. They writhe, fling, struggle. Here comes a baby with a gaff point jammed through its jaw. Here, a mother seal, bleeding in slow and thick runnels. Both, at ship's side, are rolled belly up and slit."

Similar scenes filmed in 1964 and shown on television sent shock waves of horror and revulsion around the globe. Canadian embassies were swamped by torrents of protest mail, and public pressure achieved what the warnings and recommendations of competent biologists had failed to do. A severely embarrassed Canadian government finally decided to regulate the hunt.

After a lull during the Second World War, sealing had been resumed with redoubled intensity and all the aids of modern technology-powerful ships (strengthened for travel through ice), spotter planes, and helicopters. In some years of the 1950s and 1960s, as many as 90 percent of all the pups plus large numbers of molting adults were killed. Inevitably, the seal herds decreased rapidly.

At present, an annual quota of 120,000 seals limits the kill of the Newfoundland herd by commercial sealers (60,000 each for Norwegian and Canadian ships). These are taken from the Front herd, usually in international waters. An additional 30,000 harp seals can be taken from the Gulf and Front herds by shore-based sealers in a "landsman's kill," (The total quota of 150,000 seals has not been attained in any of the last three years, when the harvest averaged 134,000.) Clubs of regulation weight and size have replaced the hooked gaffs, and helicopterand ship-borne government inspectors supervise the hunt in an effort to suppress flagrant cruelty.

Now another, more insidious development threatens the seals. With fish catches off Newfoundland and Norway declining because of massive overexploitation, the international fishing industry is increasingly interested in the vast stocks of those small northern fishes, capelin and polar cod, that constitute about 35 percent of the adult harp seal's food. Each seal eats 1.5 tons of food a year; the one million harp seals of the Newfoundland herd annually consume approximately 1.5 million tons of fish and crustaceans. Man may soon become a serious competitor for this food. Thus the future of Pagophilus-the ice-loving sealhangs in tenuous balance.

Harp seals have survived the perils of an arctic existence for thousands of years, but their adaptations to ice and inclement weather are no defense against man's twin threats of hunting them for their skins and competing for their food. If the species survives, it will only do so in greatly reduced numbers, and one of the great natural phenomena of the northern ice packs will have disappeared.

Sex and the Single Volvox

by Bradley Ewart

The reproductive life of seemingly simple algae raises complicated questions about evolution

"I had got the foresaid water taken out of the ditches and runnels . . . and on coming home, while I was busy looking at the multifarious very little animal-cules a-swimming in this water, I saw floating in it, and seeming to move of themselves, a great many green round particles, of the bigness of sand-grains.

"When I brought these little bodies before the microscope, I saw that they were not simply round, but that their outermost membrane was everywhere beset with many little projecting particles which seemed to me to be triangular. . . . This was for me a pleasant sight, because the little bodies . . . never lay still."

Thus, in a letter written near his seventieth birthday, the great seventeenth-century Dutch microscopist Anton van Leeuwenhoek first described the large, globular green alga Volvox. To see a group of Volvox colonies under a low-power microscope, gliding like green constellations through the microcosm of a drop of water, is still "a pleasant sight," with the view perhaps enhanced by modern microscopes.

Each slightly elongated, spherical green colony of *Volvox* is made up of a single layer of cells

embedded in, and separated by, a jellylike mass surrounding the water-filled interior. The "little projecting particles" of Leeuwenhoek's description are individual cells of the colony. Each cell has a cup-shaped green chloroplast, a red eyespot, and two tiny, whiplike flagella, which protrude from the colonial matrix and beat rhythmically, propelling the whole colony through water with a lazy, spiral motion. The generic name Volvox, meaning "to roll," describes this movement. The alga inhabits still waters, since rapid movements would dash its delicate structure to bits.

Volvox colonies contain from 500 to 60,000 cells, depending upon the species. In some, a delicate strand connects the protoplasm of each cell to that of its neighbors. Thus the cells are not fully independent; communication exists between them. As the colony moves through the water, it rotates on its long axis. Occasionally it may reverse and spin in the opposite direction, but it never turns end over end. Moving through the water in the direction of its "north pole," it thus has a front and rear end, a kind of rudimentary polarity. The cells in the front end are smaller and have larger, light-sensitive evespots, which enable them to direct the colony toward a source of light. These cells lack the capability to reproduce.

The only cells capable of divid-

ing to form daughter colonies are located in the posterior end. In asexual reproduction, enlarged cells, known as gonidia, begin to divide in a plane at right angles to the surface of the mother colony. As the daughter cells increase in number, they form an inward-growing pocket, like the surface of a balloon poked in by a finger, except that the cells are tightly drawn together at the surface of the mother colony. While the cells of the daughter colony are dividing and increasing in number, they do not increase much in size. The result of this cleavage is that as the cells of the daughter sphere divide, they become increasingly small and close together. This continues until the characteristic number of cells forming a colony is reached. Then further growth of the colony results from an increase in size and a moving apart of individual cells rather than an increase in the number of cells.

Before the daughter colony can proceed with its growth, however, it must overcome a serious dilemma: it has been forming itself outside in. That is, the outer surface of the mother colony has become the inner surface of the daughter colony. This means that the flagella of the daughter cells line the daughter colony's cavity instead of projecting outward. It might seem that each cell could merely turn itself around, but cytoplasmic connections between

the cells prevent any such rotation.

To solve the problem, the whole daughter colony turns itself inside out. At the point where the new colony is attached to the mother colony is a hole, the phialopore, through which the colony pulls itself in the manner of a balloon being turned inside out through its opening. The complete inversion process, beginning with a crinkling of the colony wall, takes about an hour. During inversion the young colony breaks its attachment to the mother colony and, using its newly formed flagella, begins to swim about freely inside the mother colony. A brood of ten or more such colonies eventually strains the mother colony so that the mother's wall is ruptured and the daughter colonies rush into the outside world one by one; the mother colony then dies.

Daughter colonies may form their own offspring before leaving the confines of the mother colony, thus resulting in three generations, one inside the other. Leeuwenhoek's observation of this phenomenon was later used to support the now discredited doctrine of preformation. According to the preformists' view, a miniature preformed adult, known as a homunculus, was contained within each sperm or egg. The ovists claimed that the homunculus occupied the egg. while an opposing group, the spermists, placed it in the sperm. Most seventeenth-century scholars upheld one view or the other. Leeuwenhoek himself was an ovist. Both groups supposed that the history of development of any organism, including humans, consisted of expansion and hardening of liquid organs already existing in the sex cells.

Preformists further believed that, at the time of creation, all the human generations ever to be born were packed one inside another in Eve's eggs or Adam's sperm, like the generations of Volvox inside the mother colony.

Volvox's asexual cycle may continue for several generations; then suddenly sexual colonies begin to appear. In some species, eggs and sperm form in the same individuals have cells that divide to form bundles of sperm, while females contain cells that mature into eggs.

Formation of the sperm bundles proceeds in a manner similar to the asexual production of daughter colonies. After inversion, the sperm packet wafts its way to the surface of the male colony and liberates itself. Then, depending upon the species, it either breaks up into individual sperm or remains intact as a sperm packet. In either case, the sperm make their way through the water to colonies containing eggs and then penetrate the colonies' gelatinous coverings.

The cells destined to become

eggs do not divide but merely enlarge and lose their flagella. The fertilized eggs, or zygotes, form thick, hard, outer walls and are called zygospores. In this condition, the organisms can survive the rigors of winter or the drying up of their pond or ditch. The delicate mother colony may freeze or dry up, but the tiny liberated time capsules will insure the survival of the species.

With the return of favorable conditions, each zygospore wall splits open, and the emerging protoplast begins to divide. (Volvox can spring to life almost instantly, populating a rain pool with green life overnight.) A small colony, containing fewer cells than is normal for its species forms in a manner similar to asexual reproduction. Gonidia are formed and the asexual cycle resumes. Within three generations, normal adult-sized colonies are being formed.

What causes certain cells in the colony to become reproductive cells? This question is the key to a puzzling, basic biological phenomenon. We might as well ask what causes any multicellular organism. including a human, to differentiate from a single cell into a complex multitude of cells, varying in size, shape, potentialities, and other characteristics. But in the case of Volvox, we have a much simpler model. While all the cells in the colony are similar, they do show some differ-

entiation of form and activity: multicellular organization at its

simplest level.

In 1966, while working as a graduate student at Indiana University, William A. Darden made a discovery that opened up the possibility for studying the control of differentiation in Volvox. He found that by adding a filtrate from a culture containing male colonies of the same species, young undifferentiated colonies of one strain of Volvox could also be induced to mature as male colonies. This transformation took place under conditions that would not normally produce sexual colonies.

Intensive studies at several laboratories revealed that similar sexual induction systems were operating in other species of Volvox. In some species, female colonies can be induced. Each species appears to have its own inducer substance; evidence for induction between species has not been found. Since the inducer substance is present in minute concentrations, scientists have not been able to collect sufficient quantities for chemical analysis, but it seems to be some kind of protein. Further investigations of induction systems in Volvox may help to answer basic questions of cellular differentiation.

If we collect water samples from a farm pond with abundant supplies of nitrates, we may find in addition to Volvox, several smaller organisms that have the same general colonial organization. Of course, some of these may be young daughter colonies or sperm packets, but others differ in more fundamental ways. They are completely different organisms. Volvox is only the largest and most spectacular of a series of microscopic motile colonies.

Pleodorina is slightly smaller than Volvox and may at first appear to be a daughter colony of the latter. Closer examination, however, reveals that the individual cells of the colony are larger but fewer in number—no more than 128 cells. Another difference is that at least half the cells in the posterior end of the colony

are capable of reproduction, a much larger proportion than in *Volvox*.

In the slightly smaller 64-celled colony of *Eudorina*, all but four cells in the anterior end of the colony are capable of reproduction.

Each cell of the tiny, compact, sixteen-celled colony of *Pandorina* divides to form minute sixteen-celled clusters. Then, like the opening of the mythological Pandora's box—for which it is named—the daughter colonies depart from the colonial matrix with a waving of newly formed flagella.

Simplest of the volvocine colonies is *Gonium*, which consists of four, eight, or sixteen cells united to form a curved plate or square, rather than a sphere. Like *Pandorina*, all of *Gonium*'s cells can become new colonies.

In summary, if we were to arrange the various colonial Volvocales in a series according to size and number of cells in a colony, we would find the progression from *Gonium* to *Volvox* also exhibits a gradual specialization of the cells into vegetative swimming cells, leaving fewer and fewer of the cells capable of reproduction.

The starting point of the series should be a single, independent cell, similar in form to the individual cells making up *Volvox* and other colonies in the series. This cell would be capable of propelling itself through the water with its two tiny flagella and would also be able, like all of the cells of the smaller colonies in the series, to reproduce. Such a cell does exist—*Chlamydomonas*.

In its general structure, the single-celled *Chlamydomonas* appears to represent the primitive building block from which the entire volvocine series, from *Gonium* to *Volvox*, is constructed. Its one-celled oval body is occupied mostly by a large cup-shaped, dense green chloroplast, which nearly surrounds the single nucleus and is necessary to the photosynthetic activities of the organism. A tiny red eyespot is located near the bases of its two whiplashes.

While it is tempting to regard Chlamydomonas as the primitive one-celled ancestor of Volvox, in so doing, we would be guilty of regarding one modern, living organism as the ancestor of another, a common mistake. Closer study of Chlamydomonas shows a surprising degree of complexity for such a supposedly simple unicell. It is capable of sexual, as well as asexual, reproduction. Individual cells acting as sex cells unite in every way that algae with more complex organization do. A primitive one-celled organism, however, with a body organization like that of Chlamydomonas is most likely ancestral to Volvox, its relatives, and to most higher plants and animals as well.

Volvox apparently represents a dead end in the evolutionary experiment with motile colonies. What would be the next step in the series after Volvox? Further increase in the numbers of individual cells in the colony would create a clumsy monstrosity unable to propel itself through the water. Further reduction in reproductive cells would doom it to immediate extinction. The absence of larger colonies seems to testify that Volvox has reached the limits of this type of colonial organization.

The primitive Chlamydomonas-like cells, however, apparently participated in other experiments. Some of these, like the volvocine series, were dead ends, but others must have led to types of organization allowing for further complexity in growth and differentiation. Along the way many retained Chlamydomonas-type reproductive cells as a testament to their ancestry. The biflagellate

Twelve daughter colonies, still within the confines of the mother colony, are already forming their own offspring, which appear as small dark spots.







Escape of the daughter colony from the mother: Young colonies develop within the mother, then break their attachment to her and, using their newly formed flagella, begin to swim about. Eventually, ten or more such colonies strain the mother's wall, finally rupturing it as they emerge into the outside world. The mother then dies. The escape of one daughter colony, photographed here with dark-field microscope techniques, takes about two minutes.

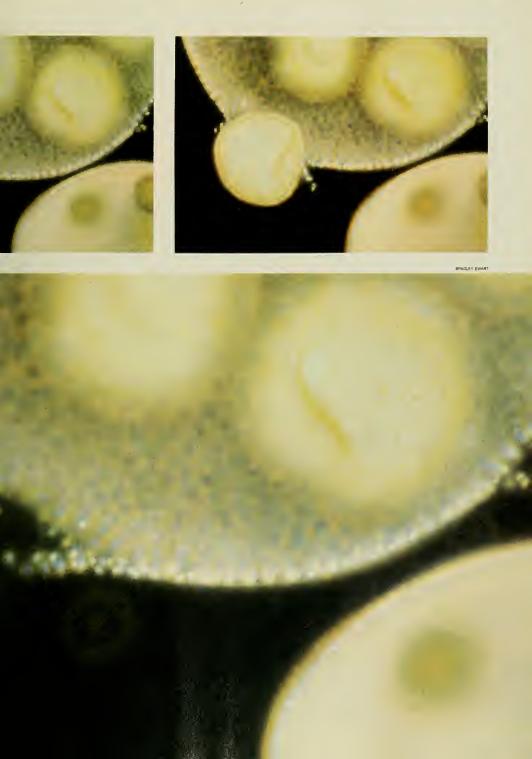
sperm of the mosses, for example, look like elongated caricatures of *Chlamydomonas*.

Is Volvox a plant or an animal? Is it a motile plant or an animal that has somehow acquired chlorophyll in its cells? Protozoologists classify Volvox and its relatives as flagellates in the phylum Protozoa. But other flagellates placed in the same group have different types of chlorophyll or lack it altogether. Botanists, regarding the combination of chlorophylls and other photosynthetic materials in the cells as a major criterion in classification (although the types of flagella are also important), place the whole volvocine series in the division Chlorophyta, or green algae. Both groups seem reluctant to give up the study of such an interesting organism. In fact, the true classification of Volvox is somewhere near the point where the plant and animal kingdoms merge.

Because Volvox contains chlorophyll, it serves as the vital link with the sun's energy in many aquatic food chains. No less important, it produces oxygen. In fact, the volvocines are not far removed from the primeval cells that first began to release oxygen, resulting in the atmosphere conducive to life as we know it today.

Since the days of Leeuwenhock, generations of biology students have delighted in discovering Volvox for themselves. It provides an example of simple multicellular organization and, along with other volvocines, forms a possible evolutionary sequence. Beyond this, Volvox is an object of spectacular beauty and fascinating activity—a microcosmic jewel.







Killers from the Clouds

by Louis J. Battan

Meteorologists are still searching for a satisfactory theory to explain tornadoes—the most vicious of all storms

On April 3, 1974, newspaper headlines from coast to coast told of an outbreak of about ninety tornadoes over a large region extending from Ohio to Georgia. The roaring funnels of intense winds blew buildings apart, shredded vegetation, and scattered debris in all directions. During a period of a few hours, more than 300 lives were lost, and property damage ran into the hundreds of millions of dollars.

Was this a once-in-a-lifetime disaster or is it likely to happen again? Climatologic records do not indicate any other single day with so many tornadoes, but storm systems responsible for more than a hundred deaths have occurred a dozen times during the last fifty years. In a memorable storm on Palm Sunday in 1965, some forty tornadoes from Illinois to Ohio killed about 270 persons. Still further back in time, on March 18, 1925, a storm, reported to be a single tornado, moved from Missouri to Indiana, killing 689 persons and injuring another 1,980. On the average, over the last ten years or so, there have been about seven hundred tornadoes a year, accounting for about one hundred fatalities. Tornadoes occasionally are observed in Australia, Europe, India, and Japan, but only the United States experiences large numbers of intense storms every year.

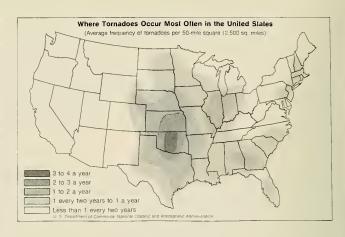
A tornado can be defined as a violently rotating column of air extending to the ground from the base of a thundercloud. The intense vortex is visible because cloud droplets form within it and dust and debris are picked up by the air.

Tornadoes come in a variety of shapes, sizes, intensities, and durations. They usually have the appearance of a funnel, a vertical cylinder, an elephant's trunk, or a narrow twisting rope. Meteorologists have various schemes to classify them. Most recently, Tetsuya T. Fujita, of the University of Chicago, and Allen D. Pearson, director of the National Severe Storms Forecast Center in Kansas City, devised a tornadointensity scale based on maximum wind speed and the length and width of the damage path. The latter quantities are related to the storm's duration and diameter, respectively.

Most tornadoes are relatively small and short-lived, with typical durations of only a few minutes. Fujita and Pearson analyzed the characteristics of the tornadoes that occurred in 1972 and found that about 90 percent of them had maximum wind speeds below 158 miles per hour, with lengths less than ten miles and path widths less than 175 yards. At the other extreme, about 1 percent of the tornadoes had wind speeds between 207 and 260 miles per hour, and produced damage paths between 32 and 99 miles long and 0.3 to 0.9 miles wide. In the decade from 1960 to 1970, about 85 percent of the fatalities were caused by 11/2 percent of all the tornadoes. Pearson refers to the strongest 5 to 10 percent of the storms (about fifty per year in the United States) as maxitornadoes. These account for most of the death and destruc-

The internal properties of tornadoes are difficult to measure because of the largely random occurrence, violent nature, small size, and short duration of these storms. Fortunately, from the scientific viewpoint, some funnels have passed over or near weather stations or places containing barographs and other instruments. Direct measurements have shown very low atmospheric pressure at the center of a funnel. Engineering studies of the damage to structures have led to estimates of the internal pressures.

Analyses of damage patterns have also yielded information about wind velocities within torTornadoes take place all over the world, but by far the largest number occur in the United States, where as many as 700 may be reported in an average year. Although these storms have been observed in all of the continental states, including Alaska, most of them are concentrated over the Great Plains and the Midwest.



nadoes. Sometimes, after a funnel moves over a plowed field, a series of circular inscriptions is observed in the soil. It has been speculated that the marks are made by debris or by small, intense vortices transported by the tornadic winds. Analyses of the photographs of the patterns allow calculations of wind speeds. Over the last few years specialized radar equipment has been used to measure wind velocities in tornadoes. From analyses of photographs of tornadoes and associated clouds, estimates have been made of the air velocities in the vicinity of tornadoes.

Detailed measurements of wind velocity, air motion, temperature, and pressure distribution within funnels at some level above the ground (for example, near the cloud base) have never been obtained. There have been discussions of flying instrumented drones through tornadoes, but that has not yet been done. The lack of measurements means that we can only speculate about the internal structure of tornadoes.

The atmospheric pressure in the funnel is lower than the pressure in the environment by amounts that have been judged to be perhaps as high as two pounds per square inch. Much larger values are cited in the literature, but they appear to be of questionable validity. Edwin Kessler, director of the National

Severe Storms Laboratory in Norman, Oklahoma, has indicated that the low pressure can be largely explained by the existence of a warm core in the tornado. The low pressure has also been ascribed in part to the dynamic properties of the vortex and the associated parent thunderstorm.

Tornadoes occur within a region of the atmosphere where there is a widespread circular motion in a counterclockwise direction. In such a circumstance, the air is said to have "cyclonic vorticity." As the air converges toward the tornado, its counterclockwise rotation increases and it rises at the edge of the funnel. Certain theoretical studies and a few observations of the appearance of tornado funnels indicate that within the funnel itself there is a core of descending air. This air would be warming with respect to the surrounding environment. The higher temperatures within the core could account, to a certain extent, for the low pressure at the center of the funnel. The sinking air would be drying out as it warms and would not contain any cloud droplets. As a result, the visible funnel would be made up of a shell of cloud droplets formed in the outer sheath of rapidly twisting and ascending air.

A notable aspect of tornadoes is their noise. People who have

had the misfortune of being under a passing tornado have reported a sound like the buzzing of a million bees or the roar of a freight train or a squadron of jet airplanes. The noise can be explained in part by the interaction of wind with objects on the ground. In some instances, electrical effects may also come into play, and the buzzing sounds might be small electrical discharges. Many tornadoes exhibit active electrical activity with frequent flashes of lightning. On occasion, funnels seen at night "glowed" as if illuminated from the inside.

Tornadoes occur most often over the central United States during the late spring and early summer. Early in the tornado season they form most commonly along the states bordering the Gulf of Mexico. As summer arrives, they are more frequent over the more northerly states and in Canada.

The formation of tornadoes depends on the characteristics of the atmosphere. The most advantageous conditions for tornado development are those that favor the growth of large, organized thunderstorms. Over the Great Plains this situation takes place most often in the spring and summer. Typical conditions are the following: At low altitudes, below about 5,000 feet, a broad stream of moist air from the Gulf

of Mexico flows northward until it encounters a frontal system composed of a cold and a warm front. These fronts serve as boundaries separating the warm air moving up from the south from cooler air moving down from the north. Aloft, a current of dry air moves rapidly toward the northeast over the humid, tropical air.

When these circumstances exist, the atmosphere is said to be unstable. It contains a great deal of potential energy that can be converted to kinetic energy in the form of strong updrafts and downdrafts. The motions of the fronts and the associated air currents and the warming of the ground and the lowest layers of air by solar radiation may initiate convective currents. When the unstable air rises, the lowest layers of air cool off less rapidly than the upper layers. This produces warm, buoyant updrafts that accelerate rapidly upward, leading to thunderstorms, which in some instances extend into the base of the stratosphere at altitudes of perhaps 50,000 feet.

The updraft is composed of air converging into the cloud from the surrounding regions. In the meteorological situations in which tornadoes occur, the general wind field has a counterclockwise rotation. As the air converges toward the thunderstorm, its rotational velocity increases. In the vicinity of a large thunderstorm system, usually along its southern flank, a low pressure system develops around which the air moves in a counterclockwise direction. This system, sometimes called a mesocyclone, might be as much as ten miles in diameter.

In some storms, for reasons that are still unclear, one or more tornado funnels develop along the southern edge of the mesocyclone. The tornado represents a further concentration of circular motion

When the appropriate meteorological conditions exist, a giant thunderstorm system can persist for periods of several hours. Such thunderstorms have been called "traveling supercells"; they require an unstable atmosphere and a wind pattern that allows new cloud development on one side of the storm while the cloud dissipates on the other side. Supercells account for the outbreak of families of tornadoes.

Scientists have offered various theories for the formation of a tornado. Fujita has suggested that a funnel forms in the following way: In the early stages of a tornado-producing thunderstorm, the updraft rotates counterclockwise. As the air ascends, water and ice particles within it grow until they become raindrops and possibly hail. The weight of this precipitation, especially in those cases where the cloud top protrudes into the stable stratosphere, initiates a downdraft. In the unstable environment of the thunderstorm, the downdraft air accelerates rapidly, while at the same time continuing to rotate in a counterclockwise, or cyclonic, direction. The twisting downdraft leads to the formation of tornadoes.

Another theory of tornadoes, advanced by Bernard Vonnegut of the State University of New York at Albany, among other scientists, proposes that electrical effects initiate and maintain the funnel. As already noted, many tornadoes display a great deal of electrical activity. Calculations of the kinetic energy of a tornado suggest that a high frequency of lightning can supply the necessary energy. The chief argument against this theory is that some tornadoes do not exhibit any unusual electrical characteristics.

The total energy of a tornado, incidentally, is not particularly great by geophysical standards. An average storm might have a kinetic energy of about 10,000 kilowatt hours and represent perhaps a thousandth the energy of an average summer thunderstorm. A tornado is destructive because its power is concentrated in time and space.

A satisfactory theory of tornadoes still does not exist. Mathematical models formulated by scientists merely represent simplified first steps. In the labora-

tory it is easy to produce rapidly spinning vortices that have the appearance of tornadoes, but such experiments are not adequately realistic simulations of atmospheric conditions.

Forecasts of tornado occurrence in the United States are made by the National Severe Storms Forecast Center. From a study of weather maps depicting the patterns of atmospheric stability, humidity, and air motion, the forecasters delineate areas where tornadoes are likely to occur. The weather observations used for constructing sea-level weather maps are collected hourly by a network of surface stations spaced about one hundred miles apart. Measurements of atmospheric conditions aloft are made twice a day at stations 200 to 300 miles apart. These posts release balloon-borne instruments, or radiosondes, that record temperature, humidity, atmospheric pressure, and wind velocity as a function of height. In view of the wide spacing of the observational stations, it is not surprising that predictions of tornadoes refer only to conditions over areas whose sides are 100 to 200 miles long.

Forecasts of tornadoes giving one to seven hours advance warning are called "watches." Statistics show that tornadoes have occurred in the predicted areas only about 30 percent of the time. On the other hand, about 56 percent of the tornadoes that caused at least one fatality were correctly predicted.

Even when a tornado forms over a predicted severe-storm watch area, only a small fraction of the people within that area are affected. In order to pinpoint a tornado, visual sighting or radar detection is necessary. At present, most tornadoes are spotted by people who report them to the authorities—policemen, firemen, or other public officials. Once a funnel has been sighted, the National Weather Service issues a "tornado warning."

Radar is widely used by the National Weather Service for observing storms that produce rain, snow, or hail. A single radar antenna can scan continuously over a region more than 300 miles wide and detect the formation, growth, and movement of thunderstorms.

It is difficult, however, to distinguish, by means of conventional radar, between severe thunderstorms that contain heavy rain and hail but do not produce tornadoes and those that do produce tornadoes. In some cases, the radar echo from a tornadic storm has a distinctive, hookshaped appendage. This is apparently caused by raindrops from the parent thunderstorm, which descend in a twisting downdraft and are carried by the winds around the mesocyclone. Hook echoes, which have diameters of about ten miles, often occur along the trailing right flank of severe storms. If a tornado develops in a storm, it often is found along the southern extremity of the hook echo.

Unfortunately, most tornadic storms do not display discernible hook echoes; the absence of these appendages cannot therefore be taken as a sign that a tornado does not exist. For this reason, visual sightings are still most reliable. Once a tornado has been observed, the parent thunderstorm can be readily followed by means of radar, and people in the storm's path can be warned of its approach.

Better techniques are undoubtedly needed for tornado detection and tracking. William L. Taylor of the National Oceanic and Atmospheric Administration has been testing a new instrument based on some relatively old ideas. It has long been known that an electrical discharge produces a burst of electromagnetic energy, which is easily detected by a radio receiver. Everyone is familiar with the crackle heard on a radio during a lightning storm. The signals received used to be called "atmospherics," but this has been contracted simply to "sferics."

About twenty years ago, Herbert L. Jones, an electrical engineer at Oklahoma State Univer-

sity, observed that some tornadoes produced abnormally high frequencies of sferics having characteristics that differed from those emitted by nontornadic storms. Jones's group was one of the first to discuss an electrical origin of tornadoes and to conduct a series of investigations on the use of sferics receivers for tornado detection. Many tornadoes, however, do not display unusual electrical characteristics. The existence of abnormally high sferics activity indicates the likelihood of a tornado, but the absence of a high level of sferics does not guarantee the absence of a tornado.

A number of atmospheric scientists, notably David Atlas at the National Center for Atmospheric Research, have been urging the development of a pulsed-Doppler radar for tornado observation. Such a radar would measure the location and size of storms as is done by a conventional radar, but in addition, it would also measure the velocity of the reflecting particles toward or away from the instrument. Since a distinctive feature of a tornado is its very high wind velocity, a pulsed-Doppler radar should make it possible to detect the presence and location of tornadoes within the instrument's range.

A pulsed-Doppler radar measures the velocity of any target by recording the difference between the frequency of the radar signals transmitted and those received. When targets, such as raindrops, are moving toward the radar, the frequency of the signals increases by an amount that

Tornadoes can level an entire town as effectively as a bomb. The damage comes from their low pressure, which causes closed buildings and vehicles to explode, and the tremendous velocity of their winds, which can carry away any object in their path.

is proportional to the speed of the raindrops. An appropriately designed, pulsed-Doppler radar can map the location and size of thunderstorms and depict the pattern of velocities, toward or away from the radar, of the precipitation particles within the storms.

The arguments in favor of an aggressive program to develop a pulsed-Doppler radar for the unambiguous detection and location of tornadoes are convincing. Visual techniques are uncertain and sometimes ineffective because of the subjective nature of the observations and the inefficiencies of the Weather Service's tornado warnings to the public. A radar could keep a con-



tinuous watch over a large area, spot storms as soon as they occur, and allow the immediate transmission of warnings via radio and television. A pulsed-Doppler radar could measure strong rotational velocities within thunderstorms pregnant with tornadoes and perhaps make it possible to predict the onset of the tornadoes. Even a few minutes of additional warning could be crucial, giving vulnerable individuals time to take evasive action.

Scientists in various organizations are working on the development of pulsed-Doppler radar for tornado detection. Over the last two or three years significant progress has been made, particularly by the National Severe Storms Laboratory under Kessler's direction.

In the future, weather satellites can be expected to play an important role in the prediction and location of tornadoes. A satellite can monitor the development of thunderstorms over a large area. Fujita has suggested that the development of tornadoes can be inferred from changes recorded in the vertical extent of severe thunderstorms. For operational purposes, it will be necessary to have a satellite stationed over the Equator south of the United States that will provide high-resolution observations at intervals of only a few minutes.

Even when it is accurately predicted, detected, and tracked, a tornado can kill and maim if warnings are not received in time or if endangered individuals fail to take appropriate action. Ideally, tornadoes might be prevented from developing or destroyed as soon as they appear. Kessler and other atmospheric scientists have examined various experimental techniques for modifying tornadoes, but none seems feasible at this time. When we know more about the nature of tornadoes and the thunderstorms that produce them, we may be able to devise a procedure for controlling them. Meanwhile, as research goes forward, safety in tornado-prone areas will have to depend on improved forecasts and strengthened building codes.



Last Dances of the Bambara

by Pascal James Imperato

As Islam and technology advance, a West African people's traditional means of social education dies away

The Bambara, a people numbering a million and a half, farm the dry savannas of Mali, where they rotate their subsistence crops among dusty plots of land. Their territory, lying in the heart of the West African bulge beneath the Sahara, stretches from the western part of Mali eastward into the bend of the Niger River and southward into the northern Ivory Coast.

Traditionally animists, the Bambara's most prominent display of their religious beliefs takes place during two annual agricultural festivals, when they perform dances that imitate the movements of animals and wear carved wooden masks or head-dresses that symbolize them. One festival is usually held in April or May at the start of the planting season; the other, the largest, after the December harvest.

The Bambara believe that certain animals possess traits that are found in men as well, and performances with zoomorphic masks serve not only to entertain but also to remind the audience of the similarities in human and animal behavior. The spectators always react to the shared traits portrayed in the dances, either positively or negatively, according to the value judgments present in Bambara society. The shrewdness of the hornbill is admired; the lion's dignity and wisdom, respected; the baboon's arrogance, scorned; and the buffalo's cruelty, feared.

Much of Bambara social organization rests upon each individual joining an age group, called a flan-bolo, when he or she reaches adolescence. In succeeding years the individual advances through a progression of flan-bolos, entering a new one every three years. The members of each age group traditionally dance with particular masks, so that by the time a person has progressed through all the groups, he has danced with most of the masks. Those in the oldest group wear the most elaborate costumes and use masks that require a great deal of skill in presentation.

During the two annual festivals, groups compete with each other in performing the dances; consequently, each group spends a great deal of time preparing its costumes and masks and rehearsing the choreography.

With the approach of a festival, flan-bolo members refurbish their masks—replacing missing cowrie shells, beads, and metal rings, and nailing or tying broken pieces in place. When the masks are in order, they are washed with water, then smeared with shea butter to give them a glowing patina.

If a mask needs to be replaced, flan-bolo members pay a local blacksmith to make a new one. Among the Bambara, the blacksmith caste carves all the masks, and because style traditions pass from one generation of blacksmiths to another, masks in a given locale remain stable, even when the animals on which they are based are extinct in the area. In most cases, the blacksmith is familiar with the missing mask, and the replacement will be almost identical to its predecessor. In the central Bambara country,

Before the annual harvest, villagers perform the n'tomo dance, which signifies man's innocence. The cowrie shells on the mask represent both the human skeleton and the multitude of mankind.









however, most large game animals are extinct and dances are performed with new masks of ill-defined sculptural form that do not resemble any specific animals.

Choreography. however, is harder to preserve and changes when an animal disappears from an area. Nevertheless, throughout Bambara country, legends, fables, and proverbs help the dancers interpret the behavior of extinct animals.

In areas where animals represented by the masks are still present, the choreography remains stable because the Bambara can observe and imitate the animals' movements. In such areas, a dance is judged by how closely it resembles the actual movements and behavior of the animal being portrayed.

Animals still commonly seen in the savanna country of Mali include the roan antelope, oribi, hyena, jackal, hippopotamus, baboon, and red monkey. Animals common half a century ago but now rare or extinct in the area include the lion, buffalo, giraffe, eland, elephant, leopard, chimpanzee, and ostrich.

Masks representing many of these animals have been in the villages for as long as elders can remember. Others are more recent, and it is often possible to learn when they were made and which blacksmiths carved them.

Some newer masks were made to replace those that were either stolen and subsequently sold to art dealers in Mali's capital. Bamako, or damaged during use. Because masks were traditionally stored by being suspended from the rafters of cooking houses, they were usually blackened by smoke. Bambara blacksmiths achieve the same result by charring the surface of their sculptures with a hot blade. Storage in cooking houses also prevented invasion by termites and wood bor-

ers. Today, masks are stored in locked trunks because they are too vulnerable to theft by the agents of art dealers.

Because all of the masks are communal property, no individual has the right to sell or otherwise dispose of them. Nevertheless, masks often disappear. In communities where animistic beliefs are faltering, usually under the influence of Islam, the theft of masks will terminate the dances.

The activities of the age groups are in decline because of the gradual Islamization of the population, the influence of Western cultural values and technology, and the migration of young men out of the rural farming areas into the towns and cities and the cash labor markets of the West African coast.

As Islamization advances, all masks are frowned upon because representational art forms are inimical to Islamic beliefs. Over an expanse of a few generations, the acceptance of Islam has resulted in the decline of many of the social and work activities of the age groups and the disappearance of the social organization enhanced by the groups. Thus, much of what is described here no longer exists in many Bambara villages and will in a few years be historical.

Before the dances begin, women and children sweep the village plaza in preparation for the performers. Soon afterward, the orchestra arrives, and the leaders of the various age groups gather their members, each dressed in his or her finest and most colorful clothing, placing them in separate areas around the plaza according to age and sex.

The orchestras generally consist of three or four drums made from hollowed-out logs, with cowhide stretched tautly over one or, in certain instances, both ends. The musicians also use various pieces of iron, tapping on them with a metal ring attached to one finger. Women augment the music by singing and clapping two oval-shaped wooden forms together. These often have

carved handles representing human or mammal heads. A xylophone is also sometimes used.

The first dance is often a masquerade called the kono and is performed by older groups. The kono represents the hornbill, a seemingly stupid bird but one that is actually extremely shrewd. The costume for this masquerade consists of a conical wooden frame, five feet high, a cloth to camouflage it, and a sculptured bird's head mounted on top. A hem at the bottom of the frame hides the feet of the two dancers inside who maneuver it about. The sculptured head, mounted on a pole some two to three feet long, is held by one of the dancers. who can raise it, rotate it, and sway it from side to side.

The bird's movable lower beak is manipulated by means of a camouflaged string, which passes up through the back of the head. Midway up the back of the camouflage cloth, a fertility symbol in the form of a humanlike puppet rests in a small pouch. Whenever the dancers stop, this puppet is made to dance up and down.

Emerging slowly from beneath the banyan or kapok trees that usually shade the plazas, the dancers in the kono take a few steps, stop, rest the frame on the ground, and manipulate the hornbill mask in all directions. During this part of the performance, the rhythm of the drums is slow, and a song sung by the women reassures and flatters the dancers.

Eventually the dancers reach the center of the plaza, pause there, then suddenly race around the plaza's periphery. Just as suddenly, they come to a complete standstill. The rhythm, whose tempo has increased during this rapid segment of the choreography, reverts to a slow cant, and the cycle is repeated several times.

According to Bambara belief, the deaf-mute quality of the hornbill representation during the dance symbolizes God's silence when he is addressed. The Bambara also believe that the hornbill announces the beginning of

Combined roan antelope and anteater headdress representing Tyi wara the cultivation season, and in this regard, the dance is important for the primarily agricultural tribe.

The kono is usually followed by the zantegeba mask, which represents the baboon. Literally translated, zantegeba means "he with the large paws." The dancer moves about bent over on two wooden poles often carved in the naturalistic form of baboon legs. The costume consists of a rectangular wood frame covered by a piece of bright, printed cloth. A heavy curtain of white hibiscus fibers hangs from the sides of the frame, concealing the dancer inside. Baboons are still plentiful in all of the Bambara country, and a skillful dancer can be remarkably accurate in imitating the animal's movements.

Accompanied by two or more men, the dancer enters the arena slowly and simply walks around the circumference, strutting like a baboon. Occasionally, he stops, crouches on his haunches, and then charges into the crowd of spectators to the delight of the women and children. In some villages baboons are feared by women since local legends tell of women being raped by these animals. Whenever the dancer dives into a crowd of female onlookers, they scream loudly and flee from the arena in mock terror.

Another dance is that of the hyena, an animal embodying the notion of imperfect wisdom. It is represented in festivals more as a pantomime than as a dance per se. There are several regional styles that the hyena's mask can take, and the costumes are generally made of locally woven cotton cloth dyed brown or yellow with herbal dyes.

Because the rapid, jerking movements of the dance can easily dislodge it during a performance, a hyena mask is always tied securely to the wearer's head. Some masks have a carved handle protruding from the chin, making it easier for the wearer to hold it in place, but most dancers keep the mask in place by holding on to the snout.

The choreography of the hyena dance requires the performer to

run rapidly around the arena and through the audience, trying to steal small, personal objects from the spectators. Often, the dancer will leave the arena and run through the deserted compounds of the village, where he steals household items. Returning to the arena, he deposits his loot in front of the orchestra. The recognition of the stolen items is cause for great delight among the owners. The fact that the hyena steals trivial items is not accidental but purposeful; it demonstrates the animal's intelligence and stupidity-its intelligence typified by its ability to steal; its stupidity, by choosing to steal minor objects.

The *n'tomo* mask, used in another dance, was once used in the ceremonies of the secret initiation society of the same name. But in recent decades it has been used for entertainment. The *n'tomo* is man as a pristine animal, as he was created by God. To the Bambara, the primal man is beautiful, inoffensive, innocent, and also aphonic, a reason why many masks lack mouths. These elongated, humanlike masks are topped by a single row of from two to eight animal horns.

The dancer's hands and feet are completely covered by a blouse and trousers. Occasionally a skirt and blouse of hibiscus fibers-their hems dyed a vivid green or purple-are worn over these. The back of the dancer's head is camouflaged with a cloth and the mask is held in place by several cords wound around the back of his head. He may carry two sticks with which he threatens the audience, symbolizing a flagellation ceremony that was once part of the initiation into the n'tomo society.

The *n'tomo* dancer is always accompanied to the arena by a large retinue of boys and girls belonging to the age group performing the dance. One of the girls carries a mirror, which the dancer uses during the performance to assure himself that, as the *n'tomo*, he has not lost his innocence.

Another dance represents the West African buffalo, an animal

In the western Bambara country, tyi wara dancers perform with only scant costuming. The Bambara believe that tyi wara, a mythical figure, encourages villagers to be good farmers.

that the Bambara consider treacherous and cruel. There are a variety of sculptural styles for the buffalo mask, and in the western Bambara country, where the species can still be found, the masks are often polychromed with vegetable dyes or modern oil paints. In areas where the buffalo is extinct, the choreography does not resemble the animal's movements, but fables and legends enable the dancers to interpret the animal's characteristic behavior.

Completely camouflaged by hibiscus fibers, the dancer enters the arena slowly and cautiously, pauses, looks around, and then moves on with a slow, shuffling gait. Having created the impression of being docile, the dancer suddenly breaks out into a tremendous run and, imitating the buffalo's unpredictable nature, charges around the arena and into the crowd, frightening the women and children, who scream and run off.

Another dance, the wara, represents different animals in different parts of Bambara territory. In the western Bambara country, the wara exhibits both the reserve and potential strength of the lion. In the eastern Bambara country, the dance describes a masquerade in which the roan antelope is represented.

The lion costume is made of grass and reeds. The performer runs into the arena where he parades with great dignity and demonstrates his fearlessness by ignoring the threats of the male spectators, who point rifles at him. He continues on his way and then, manifesting his annoyance with the crowd, makes some dignified threats with his paws.

In villages where the wara represents an antelope, the costume



consists of a massive wooden frame covered with a cotton blanket and cloth. An antelope head mounted on a pole protrudes through an opening at the top of the frame. The performers simply parade before the audience, which sings songs extolling the beauty of the roan antelope. No actual dance is performed with this masquerade.

In Bambara mythology, tyi wara is a supernatural being, half man and half animal-usually a roan antelope-who long ago taught men how to farm. He himself tilled the soil with his claws and a wooden stick from the sunsun tree. Tyi wara eventually disappeared from the world because men wasted their grain and became less conscientious in their farming. Wishing to appease his soul, the Bambara created a resting place for him. They also sculptured wooden headdresses to represent him and to remind men of the virtues he had instilled in them.

The *tyi wara* is always performed with two masks, one male and the other female. The tapering face of the male mask represents the anteater, a Bambara symbol of durability, strength, and resistance. The female mask always has a baby carved on it, a

symbol of fertility.

Although the literal translation of tvi wara is "farming animal," the words are understood to mean "an excellent farmer." For the Bambara, an excellent farmer is a man who has the strength and endurance of an animal. Unlike most Bambara dances, the tyi wara is traditionally performed on a large communal field when villagers are tilling it. On the day of communal farming, the women go out to the field early in the morning with water and food for the male tillers. The men arrive later with the village orchestra of drums and pieces of iron. As the men till, the women sing, and shortly, a dancer wearing the male headdress emerges from the bush nearby followed by a dancer wearing the female headdress. The two move alone across the



Lion mask

Baboon mass

vacant field, bent over on two wooden sticks of the sunsun tree, and gradually shuffle to the spot where the men are farming.

The song of the *tyi wara* extolls the virtues of a good farmer and encourages men to follow suit. Both of the dancers are camouflaged in veils of hibiscus fibers blackened with mud.

In the western Bambara country, where roan antelope are still present in great numbers, the choreography imitates the motions of the antelope, with the dancers jumping high into the air toward the end of the dance. The height jumped represents the height to which the Bambara believe the good farmer's millet will grow. In the east, where the roan is now extinct, the choreography contains no elements of the roan's behavior.

The intentions of the Bambara are not subtle; their purposes are clear-cut and have, for unknown centuries, influenced the moral and social behavior of the people. Man is extolled to live up to the dignity of the lion and to scoff at, but be wary of, the antics of the baboon. Through the series of strict age groupings, each with its own masks, dances, and moral messages, all Bambara receive an ever widening and more complex social education extending from adolescence into early middle age. But with the increase of Islam, the developing technology, and the migration to urban areas, this socialization process is fast disappearing.



Notes from the

First Frontier

Out of the hill country of northern New England—a tribute to its farmers Spring 1971, north of Fairlee, Route 5, which runs along the Connecticut River on the Vermont side. Three days ago a quiet country road, yesterday they opened three sandpits within a four-mile stretch, and the ten-wheel fifty-ton trucks are crashing by at the rate of five per minute—the roadhead of Interstate 91. There are half a dozen state cops directing traffic, while two men repair barbed wire fence that separates the road from daisy-studded lush-green pasture. Stripped to undershirts, with straw hats—slow, steady under the hot spring sun, chewing tobacco, in harmony with the cows they will soon release into this field. Moving at that pace they do not relate to the repetition, the speed, the number, the size of the thundering trucks. These two farmers, their heads absurd, out of synch with their patiently, expertly, persistently working bodies, whip, are jerked around 180 degrees, in amazement at the passing of each truck.

William Cobbet, almost exactly 150 years ago, wrote, "I heard some laboring men talking and they having observed that the roads had become so wonderfully better in the last seven or eight years, I said, 'It is odd enough that the roads should become better and better and the farmers become poorer and poorer.' They looked at one another . . . and at last one of them said, 'Why, it is because the farmers have not the money to employ men so they are put on the roads.'



'Yes,' said I, 'but they must pay them there.'"

Probably the methodology is cockeyed. We should listen to our poets. For instance, in the late 1950s some intellectuals noticed that massive, nationally centralized public works programs tend to destroy neighborhood life; by the 1960s even popular journals were receptive to the notion. Listen to Casey Bill Weston in the 1930s:

So I havta try find me some other place to stay, That house wreckin crew is comin from that WPA

There is an intimate connection between the growth of nationally centralized (for the honor of etymology, 1 refuse to call them *federal*) public works, superroads, chain stores, agri-industry, and the disappearance of the small farmer. But although the supermarkets' and dairies' central purchasing offices prefer to deal with giants of their own scale, the small farmer refuses to disappear entirely.

What is a farmer? Bureaucrats have lately been beating the corners of their committee rooms in Concord and Burlington for an answer to that. No one asks the farmer, nor would he say. "Not about to stand up in a room so them fellas can make fools of 'em with words." If you want to talk to a farmer, do it on his own land, in the wintertime, when all he has to do is snowplow the drives and

Plow when the fields have dried. Plant when danger of frost is past. The conditions are subtle."

THE GRANGER COLLECTION





Northern New England enforces a humble, complex, patient, ironical approach.
The most beautiful spring day is remarked on with 'Can't complain.'"

barnyards, feed the stock, milk the cows, clean the barn and milking equipment twice a day, repair his buildings and equipment, plan next season's work, spread his manure.

There is a lot of conversation about manure around here, what kind is good for what purpose:

Old Lady: What do you use on your strawberries?

Old Farmer: Well-rotted horse manure.

Old Lady: That's funny. I use cream and sugar on mine.

When an old henhouse of commercial size is advertised to be cleaned out, a fierce competition ensues: men, women, children—respirators and bandannas over their mouths—wielding shovels, scrapers, forks. The first to come get the upper floor if there is one, from whence the caked and powdery dry manure can be thrown directly into the truck. Many people are aware of and talk about N, P, K, Ca, and Mg (pronounced "mag"). Other avidly sought commodities include hardwood ashes, old railroad ties, and telephone poles for fenceposts.

Farming has been on the decline here for 150 years, in this hill country of northern New England, rising north of Concord, New Hampshire, and North-hampton. Massachusetts. The roads still follow the valleys of the Connecticut and Merrimack rivers. The first boomland of the new nation. 1790 to 1810, a rush of settlement, all these towns opening in a decade, filling with prosperous, landowning families. Land free for the taking, for the clearing; land that provided its own energy, that provided all that was needed for life, plus increasing in value while supporting you. Sending for their friends and relatives from London, Boston, Providence. "The Age of Self-Sufficiency." Taxes could be paid in labor. About ten dollars cash a year sufficed. An annual cattle drive to Springfield or Hartford, or (1820) "sleds . . . to Boston with dead hogs, pork, butter, cheese etc., and load back with store foods. They have generally two horses and travel 40 miles a day with a ton weight." Several friends making the annual trip together.

The decade from 1810 to 1820 brought a series of blows. First, the war—White River Junction, in the heart of the hill country, is as close to Montreal as it is to Boston, and Champlain's plains are a classic battleground. Then, "subsequent economic dislocation," capped by the weather of 1816. "On June 8 a foot of snow fell and blew into drifts two and three feet high. There was a little snow in July and August and a heavy frost on September 10. Almost no crops were harvested that fall." Although few humans starved, the population fell drastically, as the newly opened lands of Ohio attracted hordes of discouraged New Englanders. Population growth moved westward and our history books follow. Those

who remained behind? Contemporary testimony, 1839, "The almost universal condition of the inhabitants of Lyme [an upper Connecticut Valley town in New Hampshire] is the possession of an abundance of the good things of life."

The farmer's capital is flexible. It is land, improved by labor and intelligence. In the eighteen thirties and forties wool, like beef, pork, and maple sugar, became a cash crop. The completion of the railroads to the west brought the overwhelming competition of western range wool and beef, whose cheapness was achieved at the cost of the destruction of much federally owned grazing land.

They held on, switched from wool to butter and cheese, from butter and cheese to whole milk, or took "workin out" to supplement the living the land provided. They do hold on. I met a man at Quoddy Head National Park in Maine. "I have my own everything—beef, milk, pigs, turkeys, ducks, geese, sheep, apples, berries, garden, 150 acres. I dig clams in my front yard, got a pilot's license, we all go to sea." His great-grandfather had settled there. A short, truculent-looking Welsh sort of brownish man, he bandies up to me and, hands on hips, says. "Do you mind if I ask ye a question?" with a lovely rising interrogatory lilt, music of old English, e liz a beth.

Says I, "Sure. . . ."

Which he takes, as it was meant, for encouragement and asks, "Do ye like steamer clams?"

A vegetable garden as an art work is precisely comparable to any genre, forty sets of five months each, grand in scale, intricate in detail, cornleaf darkgreen tongues run ninety-day-long changes in *n*-part harmony.

The spray of elderberry branches through the mounded snow. Newly every day it is given—by wind, earth, sun, water, worms, N-fixing bacteria. predacious fungi, all classes and orders including, in their place, four generations of men who have tended this elderberry, garden. maple, land, drainage canals—all that makes farm. And they have done not so badly (may I do as well!) though the farm be shrunk and sandpit gouge, overbuilt road welt scar the bottomland lying rich; pastures rising beyond in the absolutely innocent, purely sexy swells and curves, geometry of any virginal, fertile young girl, young horse, that forgotten beauty.

Freshness resides, as the craftsmen patiently learn, not in newness.

How many centuries spent The sedentary soul In toils of measurement Beyond eagle or mole, Beyond hearing or seeing, Or Archimedes' guess, To raise into being That loveliness?



FROM Vermont Album, RALPH NADING HILL. THE STEPHEN GREENE PRESS, © 1974

A lot of what a farmer does is carrying. From the middle of his cows he takes milk and carries it to the milk house, where he separates it into cream, milk, cheese, buttermilk, skim milk, and whey," To finish wood, rub with warm linseed oil "once a day for a week, once a week for a month, once a month for a year, once a year thereafter." A car ten years old is despised or a curio, while a thirty-year-old Snap-On #2 Phillips Screwdriver is treasured. The undulations of the land, shake of pubescent hips, extend the glaciations; the beavers returning century after century to harvest the new generation of aspen, the silt settling tenderly through murky enough waters, through which the backhoe rackets in one afternoon. Tens of thousands of acres of sandpits in the hill country. They truck our land away to be the long mounds of that strangest of ceremonial objects, the interstate highway system.

Reversing the process of creation, Going from the seventh day to the first.

Take the battle of the Marne, a familiar example of the extension of human spirit, demonstrating what folk can do when they drop their prejudices and relax. A spirit of gaiety seized them, report sober historians, and as if people can only work at their best for insane ends, the farmer is nowhere in history, id. damn est "histories." Yet the man who has "kept up" a hill farm in northern New England for forty years has made an expenditure as great and synergetic (that sudden welling up of harmony as psychological barriers are dropped), has accomplished an earthly work, oeuvre, as detailed, unique, universal both in execution and comprehension as any heroism of a Beethoven, as any trench confession.

And it is by no means hard, if you can match orbits enough, to talk to a farmer on his own ground (no metaphor that!). No means hard to understand this. "Our first lambing," said the eighty-year-old lady, ". . . didn't have our clothes off for two weeks." Or, "Mott was away . . . I put my boots on . . . carried that calf right into the bedroom . . . and when Mott came home . . . kept him there for two weeks takin' care of him just like a baby. . . ." Newborn Herefords average seventy-five pounds, a woman under five foot tall talking, telling her stories with all the detail that great adventures deserve, and with the irony? humility? cynicism? that great adventures deserve: "He made a nice piece of meat."

A lot of what a farmer does is carrying. The farm wagon (pickup truck) is a basic implement, and as late as the nineteenth century most of European civilization's capital investment in transportation was in this form, taking precedence even over the military. Start anywhere in the cycle. The farmer cuts the fields and carries the hay, grain, and straw to the barns and stores it in the lofts, bins, silos. During the winter he carries hay and grain to the front end of his cows (and water, which on this farm is conveyed through the pipe his grandfather laid in a four-foot-deep hand-dug trench a quarter of a mile through the rocky side hill from the cistern his great-grandfather built).

From the middle of his cows he takes milk and carries it to the milk house, where he separates it into cream, milk, cheese, buttermilk, skim milk, and whey, some of which he carries to market or his house, the remainder of which he carries to his pigs, chickens, young stock. To the rear end of his cows he carries straw, which he spreads on the barn floor; from the rear end of his cows he carries manure and urine-soaked straw to his fields, where he spreads it and plows it in. Cycle.

Or he carries sap from the maple trees to his evaporator. He carries split dried hardwood (often maple grove thinnings) to his evaporator. From the sugar house he carries maple syrup and sugar to his storeroom and to market, and wood ashes to spread on his field.

And these cycles of carryings connect to and depend on other cycles of carrying. The maple's roots carrying calcium and potash from the deep water-soaked rocks, the maple pumping up the sugar manufactured and stored the summer

before. And in all this transport, the speediest way is not necessarily, indeed only rarely, the most efficient. "Make hay while the sun shines." Does everyone know that hay needs sunshine to cure correctly? If it be rained on between cutting and shocking it be ruined. (I resurrect the subjunctive ut omen absit.) Plow when the fields have dried. Plant when danger of frost is past. The conditions are subtle. In the spring the young plants need enough water to metabolize but not so much that the fields are too wet for weeding to be carried on efficiently, effectively.

And here particularly the climate is too untractable, too unpredictable to be subdued. In the flat and wide valleys of California's summer drought region, mere engineering can reduce the land to a predictably productive mechanism (for how long is another question). In those valleys there are dependable months of sunshine and a suitable mineral medium for a seedbed. Merely carry the water and nutrients to the plants. Voilà. The twentieth century opened with the Imperial Valley. My childhood books of world wonders understood this clearly.

Northern New England enforces a more humble, complex, patient, ironical approach. The most beautiful spring day is remarked on with "Can't complain."

Once I asked an old farmer, "Think it's gonna rain?"

"What do you think?"

I looked up and said, "Mebbe, mebbe not."

He looked me, at last, in the eye and said, "That's right."

And so we come back to the first frontier. The hill country, the north country. The farmers are leaving as usual. The past year has been especially disastrous. Yesterday, two men spent an hour telling me not to go into farming. We were in the sugar house, which the younger man had rebuilt after it burned to the ground, uninsured. In which, having closed down his lucrative well-drilling business for the season, he was making maple syrup, sugar, maple cream, tapping over 2,600 trees, because his father did it for forty years, because it is fun, because the family mixed farm in northern New England is the only stable ecosystem on the North American continent that includes white men, because of the climate, because of a mixture of Scandinavian, German, and Amerind domesticates and techniques, because he was pre-adapted to it. . . .

Clover, timothy, corn, beans, squash, flax, sheep, pig, cow, chicken, turkey, duck, blueberry, maple, birch.

Honor, honor to the dying land.



I he farmer cuts the fields and carries the hay, grain, and straw to the barns and stores it in the lofts, bins, silos. And in all this transport, the speediest way is not necessarily, indeed only rarely, the most efficient."

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Solar Bubbles

Clouds of hot plasma erupt perpetually from the sun's corona. A single burst involves enough energy to fill United States' energy requirements for several hundred centuries

The sun is surrounded by a hot, rarefied atmosphere, called the corona, that extends millions of miles into space, merging imperceptibly into the interplanetary gas. Far dimmer than the sun's familiar yellow disk, and even fainter than the blue daytime sky, the corona is only visible during a total solar eclipse. On such occasions, when the moon hides the sun's brilliant surface, the corona is revealed as a pearly white, irregularly shaped halo, which often contains long radial streamers amidst the diffuse glow. Photographs made recently from the Skylab spacecraft show that the corona is the site of dramatic eruptions of immense clouds of hot plasma, an electrified gas consisting primarily of protons and electrons, together with helium atoms that have lost an electron. The sun is literally blowing bubbles. The Skylab photographs provide visual evidence that favors a theory proposed in 1959 to account for solar-induced magnetic storms on the earth. Further, comparison with old records indicates that the newly discovered phenomenon of plasma clouds was actually first seen more than a century ago, although it was not then understood.

For thousands of years, studies of the corona were limited to the brief moments of total eclipses. At one time astronomers even debated the question of which celestial body the corona pertained to. Was it really an outer region of the sun? Or was it instead a









HIGH ALTITUDE OBSERVATORY, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

A huge ascending loop of plasma that rose through the solar corona can be seen in a series of photographs taken from Skylab on June 10, 1973. normally invisible atmosphere of the moon (as Johannes Kepler suggested in 1605), discernible during a solar eclipse when backlighted by the sun? Some even thought it an optical effect in the earth's atmosphere. Needless to say, the brief moments of eclipses were much prized. C.A. Young, a pioneer investigator of the coronal spectrum, reported his observations of the eclipse of 1869, in which totality at his Burlington, Iowa, viewing site lasted two minutes, fifty seconds: "I cannot describe the sensation of surprise and chagrin, of wasted opportunity, personal imbecility, and complete exhaustion which overwhelmed me when the sunlight burst out." Most regretted were the few seconds when Young, fascinated by the direct spectacle of the eclipse, left his telescope unattended.

Gradually, as reports from successive eclipses were compiled over the years, it became clear that the shape and structure of the corona change slowly in rhythm with the eleven-year sunspot cycle. In particular, the corona is most spherical in the years of greatest sunspot number and most elongated when sunspots are fewest. To extend the practical observing time of an eclipse, astronomers adopted the stratagem of racing the moon's shadow in a jet aircraft. This culminated in the eclipse of 1973 in the flight of a supersonic aircraft down the eclipse path, providing seven scientists on board with an incredible seventy-four minutes of totality. But eclipse observing as a method of recording the visual appearance of the corona was even then becoming obsolete.

The National Aeronautics and Space Administration launched a satellite—Orbiting Solar Observatory-7—in the fall of 1971 that



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provided an alternative to the eclipse trip. OSO-7 carried an instrument, the white light coronagraph, that made its own eclipse, when so commanded, by blocking the sun's disk with an occulting device mounted on a boom in front of a telescope. Television pictures of the artificial eclipses were relayed to a control center at the Goddard Space Flight Center in Greenbelt, Maryland.

Astronomers, however, will always go to places where true eclipses can be seen. There are usually new experiments to be performed that are unsuited for flight on a satellite or are conceived after the last launch opportunity has passed. And there are auxiliary studies by scientists of every description, who investigate the behavior of flora, fauna, and natives during an eclipse. Knowledge about the cause of eclipses is still incompletely disseminated. As recently as December 3, 1974, the Associated Press reported that sixteen Cambodians died when superstitious soldiers in Phnom Penh fired their weapons during a lunar eclipse. The reactions of animals to eclipses of the sun seem to attract particular interest. One watches to see, for example, if chickens will come home to roost or if other animals are tricked into thinking that night has fallen. A nineteenthcentury observer of eclipse-struck roosters reported that one cock fell asleep for ten minutes as totality neared, then awoke and "uttered a surprised expression but did not crow." At a 1963 eclipse in a rural Quebec village, I noted that at the moment of totality, birds circled low, dogs barked, schoolchildren began to parade, gesticulating men ran out of a saloon, glasses in hand, and (a sign of modern times) the automatic streetlights came on.

For corona pictures, however, the satellite method has proved itself. The first major result from the OSO-7 coronagraph, obtained by scientists of the Naval Research Laboratory in Washington, D.C., under the direction of physicist Richard Tousey, was the observation of a great outburst on December 14, 1971. Pictures transmitted by the satellite on that date showed a series of bright plasma clouds shooting out

of the northeastern sector of the corona at speeds up to 2.5 million miles per hour. The largest clouds measured about thirty times the earth's diameter. Rapid phenomena in the corona had been detected previously by radio telescopes, but the OSO-7 discovery showed that these coronal transients are actually visible under the right conditions.

The event of December 14 seemed to originate from the collapse of a bright streamer recorded by the satellite on the previous day. On subsequent occasions, however, the coronagraph observed a variety of transient phenomena, generally with less obvious causes. These included a short-lived curved streamer, rapid changes in the width and intensity of other streamers, a general outflow of all material (called the interplanetary blast) in a large region of the corona, and the occurrence of a big loop of plasma, several times the size of the solar disk. In all, about a dozen of these phenomena were recorded during the first twenty months of OSO-7's orbital lifetime, although the coronagraph was turned off much of the time while another onboard solar instrument made ultraviolet measurements.

In 1973, a more powerful white light coronagraph was put into orbit in the payload of the manned spacecraft Skylab. Developed by solar physicist Robert MacQueen at the High Altitude Observatory in Boulder, Colorado, it obtained much sharper pictures than the OSO-7 instrument and recorded them on film. About 100 coronal transients were found on the roughly 35,000 photographs taken with the Skylab coronagraph during the 81/2-month mission. Ernest Hildner, also of the High Altitude Observatory, classifies these in two categories: transient phenomena in which the recognizable shapes within the corona are rearranged without the apparent supply of fresh material from lower parts of the sun, and mass ejection transients in which resupply does, in fact, occur. Frequently, events of the latter kind are "bright loops ascending outward through the field of view of the coronagraph."

An outstanding example of the bright ascending loop phenomenon was photographed from Skylab on June 10, 1973. It was preceded and undoubtedly stimulated by an eruption at a lower level in the sun, which was recorded at 08h15m Greenwich Mean Time by ground-based solar telescopes. Astronauts Charles (Pete) Conrad, Joseph P. Kerwin, and Paul J. Weitz were asleep on Skylab, but the coronagraph was operated by ground command from 09h29m to 10h01m, when the spacecraft passed beyond range of a suitable ground station. MacQueen and his colleagues. including eclipse expert John A. Eddy, measured this series of 144 photographs and found that the loop had grown to more than 100 times the diameter of the earth and was racing outward at a speed in excess of one million miles per hour by the time the last photograph was taken. As the energy crisis continues here on the earth, we may ruefully note that the energy involved in expelling this loop from the sun,

as estimated by Hildner, equals the total energy requirement of the United States for the next 500 centuries, assuming that consumption is restricted to the 1970 rate.

Loop structures in the solar atmosphere are widely believed to trace the outlines of regions of enhanced magnetic field. Thus, the ascending loops photographed from Skylab presumably reveal the expansion of magnetic field configurations from the sun into interplanetary space. They call to mind a theory proposed by cosmologist Thomas Gold. In April, 1959, at Washington, D.C., Gold summarized his ideas on this subject at a symposium on the exploration of space sponsored by the National Academy of Sciences, NASA, and the American Physical Society.

Gold was concerned with the method by which solar plasma ejected in major eruptions reaches the earth and stimulates magnetic storms. A magnetic storm is a worldwide disturbance with such symptoms as rapid fluctuations in the earth's magnetic field at ground level, the occurrence of auroras in the upper atmosphere, and the disturbance of the Van Allen radiation belts in the magnetosphere. Magnetic storms are often accompanied by interference with long-distance radio communications.

In 1959 no direct spacecraft measurements had been made in space outside the earth's vicinity, but Gold reasoned from two fundamental observations made on the earth. First, a large magnetic storm usually begins abruptly, in a time span as short as one minute. Second, during such a disturbance, the number of nonsolar cosmic rays-cosmic-ray particles thought to come from outside the solar system-arriving at the earth decreases. (It was discovered last year that some of these particles come from the planet Jupiter.)

From the first observation, Gold concluded that the ejected plasma cloud did not diffuse rapidly into its surroundings, as it would if it were an unconfined

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gas. Rather, he argued, it must be restricted by a fairly distinct geometric surface at its leading edge. From the second observation, it was clear that as the solar cloud approached the earth, it deflected or swept away the usual flow of nonsolar cosmic rays. One simple physical entity, an expanding magnetic field structure anchored at the sun, could produce both effects. In particular, Gold proposed that the occurrence of an eruption inside a coronal loop causes the loop's magnetic lines of force to stretch out into space, so that the loop and the plasma within it will reach the earth at a well-defined time and thus cause the sudden onset of a magnetic storm. In addition, the magnetic field of the loop deflects the nonsolar cosmic rays that are exterior to it, accounting for their decreased occurrence at the earth during a magnetic storm. It appears that the ascending loops in the corona, as photographed from Skylab, actually represent Gold's once hypothetical process in action.

Confirmed or probable records of total eclipses of the sun date back as far as May 3, 1375 B.C. when (according to a modern interpretation of a clay tablet written in the oldest known decipherable alphabetic script) "the sun went down" in the daytime in ancient Ugarit, a kingdom in the region of present-day Syria. In all of that long history, might not a coronal transient have been seen during an eclipse? No sightings were reported as such, but a viewer whose inspection of the corona was limited to the few minutes of eclipse totality might not have perceived the fleeting nature of a single structure within it. Thus, Eddy reasoned that a transient might have been recorded as though it were a stable feature. Further, taking into consideration the occurrence rate of transients, as deduced from the Skylab photograph series, and the average duration of a total eclipse, he calculated that perhaps once a century, a transient would be in progress when an eclipse occurs. On this basis, he looked through old photographs and drawings of eclipses and discovered what is almost surely the record of an ascending

loop, much like that of June 10, 1973, in the observations of a famous eclipse that took place in 1860.

The path of totality of the solar eclipse of July 18, 1860, passed across Spain. Several months earlier, Scientific American had reported that "at least forty astronomers, from various parts of Europe, intend visiting that country on the occasion, in order to observe the phenomenon." Clearly, an eclipse of the sun was not yet quite the international extravaganza it is today. At the 1972 eclipse, the almost 4,000 observers, many of whom arrived in a long procession of nearly identical silvery campers, about equaled the permanent population of Cap Chat, the prime viewing site on the Gaspé Peninsula, Quebec. A year later, just before the great solar eclipse in Africa, a host of eager amateur astronomers swarmed through New York's John F. Kennedy Airport headed for Kenya, marshaled by a leader with solar arm patch and bullhorn, while other viewers set off for the eclipse track in chartered

ocean liners. The 1860 eclipse was a landmark in solar studies, for it was the first to be extensively photographed. The photographs were primarily useful in recording prominences, bright red protuberances on the edge of the solar disk, very low in (or in the thin layer below) the corona. In a discourse on the eclipse, given the following May at the Royal Institution, the famous English physicist Michael Faraday exhibited several photographs of the event, including two taken during totality. They showed the prominences very clearly and helped to confirm that they are genuine appendages of the sun-a fact not then universally accepted. To depict the corona properly, however, Faraday was obliged to use a drawing, which showed the faint outer coronal regions that did not register photographically. For the same reason, Eddy was obliged last year to use a series of 1860 eclipse drawings to demonstrate his contention that the nineteenth-century astronomers had actually seen a coronal transient.



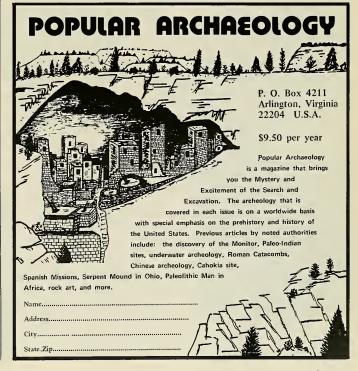
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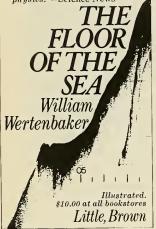
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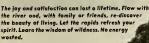
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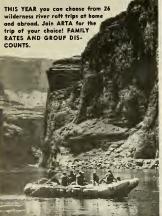
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Although most observers of the 1860 eclipse were stationed in Spain, the eclipse track actually first crossed inhabited parts of northwestern America. It was seen from the then Washington Territory by a Lt. J. M. Gilliss. who set up camp on Muck Prairie, not far from modern Tacoma. Gilliss watched the celestial show low in the sky after sunrise. When totality came, he wrote, "beads of golden and ruby-colored light flashed almost tentatively around the moon, not constant even for a second at one point, but fitfully flashing as a reflection from rippled water. . . . It became so dark that an assistant held a lighted lantern to enable Gilliss to read the seconds dial on his gold chronometer and thereby time the events of the eclipse. Totality came about two hours earlier for Gilliss than for the astronomers in Spain. His full report contains no hint of the ascending loop identified by Eddy in the reports from Spain. Since Gilliss was an experienced observer, having journeyed to Peru for an earlier eclipse, it seems reasonable to conclude that the loop might not yet have emerged at the time of his observation. It may have been seen through a small telescope by a Lt. E. D. Ashe an hour later in Labrador, but he viewed the spectacle through clouds, and his report of a long "white flame" in the southwestern corona remains tantalizing but highly uncertain. There were other astronomers at Ashe's site on Ungava Bay, but none glimpsed the corona

On the other hand, there is ample evidence of a loop in the drawings of the 1860 eclipse made during the eleven minutes that elapsed as the moon's shadow crossed Spain from the south shore of the Bay of Biscay to the coast of the Gulf of Valencia. (From there it continued over the western Mediterranean, passing directly over Ibiza in the Balearics, and on into Algeria.) In fact, C. A. Ranyard, who prepared a compendium of eclipse observations for the Royal Astronomical Society in 1879, noted that twenty-one of the European observers had seen a large curved structure in the southwest corona

through the clouds.



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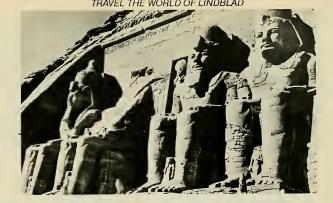




at the 1860 eclipse. It was most pronounced in a drawing by the Italian astronomer Guglielmo Tempel, which was reproduced in the Annals of the Royal Physical Museum of Firenze. Indeed, Eddy notes an uncanny resemblance between this old drawing and the Skylab photographs of the coronal loop of June 10, 1973. Even more convincing is the tendency in the drawings made at the 1860 eclipse for the putative ascending loop to become more conspicuous and extend farther out into the corona as the eclipse advanced across Spain. Eddy's calculation from those drawings indicates that the expansion velocity of the curved structure was in the same range as the velocities measured in confirmed coronal transients recorded by the OSO-7 and Skylab white light coronagraphs.

It must be admitted that there are some considerable differences among the reports of the Spanish eclipse. A Mr. Bryne thought the corona resembled "the glory round the heads of saints in pictures," while two professors from Bordeaux, named Lespiault and Burat, explicitly noted that the corona was not like a saint's glory. Father Angelo Secchi, Director of the Roman College Observatory and one of the most distinguished astronomers at the eclipse, noted that grasshoppers quieted down and a bat flew out as the sky darkened, but he did not see the coronal loop, although totality came for him at the same instant as for Tempel. (Ranyard believed that Secchi and two other observers were dazzled by light from a bright, lower region of the sun.) Nevertheless, it seems likely that a solar discovery made with satellites in the 1970s was actually anticipated by the astronomers of a century ago. Even the simplest contemporary records of a natural phenomenon may similarly be vested with unforeseen significance in a future age.

Stephen P. Maran is project scientist for Orbiting Solar Observatories at the Goddard Space Flight Center in Greenbelt, Maryland. His articles on Comet Kohoutek appeared in Natural History in March and October of last year.



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SHANNON CORPORATION Dept. 45N 734 N. Decatur Ave., Minneapolis, MN. 55427 mixture of water, invert sugar (a crystalline variant of sucrose). dirt, and on occasion, sugar lice. The refinery where these last remnants of botanic reality are filtered out is, in our day, a marvel of automation and complex processing. But even in the beginning of the West Indies sugar trade, refineries tended to be built in the temperate clime of the colonial mother country, where sugar technicians could coolly perfect the raw product of tropical slave labor.

This arrangement, like everything else to do with sugar, was entirely artificial. Cane was not one of those New World flora brought back by Columbus to a wondering Europe. Instead, Columbus imported plants to Hispaniola on his second voyage, in 1493. The infant industry was at first a fizzle, until slaves could be shipped in to apply their cut-rate energy to the satiation of the white man's craving for sweetness. Since then, the Western world has had a cheap source of pure saccharine energy. Sugar is a staple of the industrial world. Americans down about 100 pounds of it per person annually. This works out to the astounding total of 450 calories per day. The British habitually consume even more. And so it is no surprise that poor countries bent on industrializing themselves have fastened on white sugar as a crucial mark of advanced civilization.

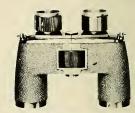
Consequently, rampant worldwide demand for refined sugar has, according to the sugar producers' best explanation for last year's zooming prices, created a shortage of supply. Of course, not everyone has completely swallowed this line. It remains difficult to understand why or how the Third World's developing sweet tooth could cause both a scarcity and large "windfall" profits for sugar manufacturers. At this writing, a number of major sugar companies are under indictment.

Whether or not the manufacturers conspired to jack up the wholesale price of sugar to opportunistic heights, the sugar panic of 1974 did expose numerous problems in the world of sugar. For one thing, ordinary people saw the dangers of a highly



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centralized supply system for basic foodstuffs. They realized that just as an extremely small number of grain wholesalers had recently contrived to disrupt the world wheat market, so too the sugar barons might easily have concocted a scheme to rape the public, using scarcity as an excuse. The take-home lesson here is that sugar does not grow on trees but in the refineries of a small club of giant corporations.

The second revelation of the sugar panic was a shock to the average grocery shopper, who suddenly saw how sugar-ridden his food world was. Prices shot up all over the supermarket: on soft drinks, baby foods, jams, cereals, almost wherever one turned. Sugar, it dawned on us, is no longer a matter of choice. In only a few decades, sugar addiction has sneaked into the bloodstream of Western society. But, if we are now spreading our saccharine habit to the Third World, it was, ironically, in the very capital of underdevelopment, India, that a European first tasted sugar. Nearchus found it in the Punjab while invading the subcontinent with Alexander in 325 B.C. That original sugar, a crude, dark brown, uncentrifuged product boiled down from crushed cane in an iron caldron, is still made in India today under the name jaggery.

This proto-sugar spread eastward to China and Japan, despite its impurities. By the sixth century A.D. it had reached the Middle East, where, in 1099 at the siege of Acre, European crusaders ate it (or some other version of sugar) as an emergency ration. Eventually, Europeans transplanted cane to Sicily and the Canary Islands, where Columbus acquired his fateful cargo.

Did he suspect, as he skirted the wide Sargasso Sea, that he was making it possible for future generations to grow up with lollipops in their months? What would Columbus have thought of cereals, like Quisp and Sir Grapefellow, that contain more than 30 percent sugar? Certainly, he could not have guessed the amount of human ingenuity it would take to manufacture cream-center chocolates.

Indeed, the technology of sugar

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candy is so intricate that few nonprofessionals have mastered it. Even an apparently simple sweet like fudge is a challenge to the neophyte confectioner since it requires an exact touch and a knowledge of how sugar behaves when it is heated to the boiling point and beyond. Basically, what occurs is that the crystalline structure of sugar changes progressively as the temperature rises. Each new kind of crystal will cool into a particular kind of candy. The several stages of crystallization are named according to the result produced by dropping a small amount of hot syrup into ice water. Syrup from 230° to 234° F. will turn into a coarse "thread." From 234° to 240°. syrup makes a "soft ball" that flattens by itself when picked out of the water. From 242° to 248°, you get a "firm ball" that will hold its shape unless pressed. From 250° to 268°, the syrup makes a "hard ball" that is, nevertheless, still malleable. From 270° to 290°, hard threads form; they will bend, though, at this

"soft crack" stage. From 300° to 310°, sugar turns hard and brittle, the "hard crack" stage. Finally, from 310° to 338°, the syrup begins to caramelize, to turn dark and gold. At 350°, it

goes black and burns. Clearly, it is much easier to be sure what stage you have reached if you have a candy thermometer. Only experts can guess temperature from the look of the syrup. The other major difficulty in sugar cookery is known as sugaring. For example, fudge often turns grainy. This occurs if crystals on the side of the pan have been stirred back into the syrup. which has crystals of a different structure. The bad crystals multiply and subvert the good ones. This will not happen if you follow the directions precisely in the recipe below. It calls for maple syrup (83 percent sucrose), in a feeble but delicious gesture of protest against the monopoly of white sugar.

Raymond Sokolov is a free-lance writer and food columnist.

Maple Cream

1. Take any amount of maple syrup and heat it to the soft ball stage. This is trickier than it sounds. First of all, calibrate your candy thermometer by setting it in a pan of boiling water. The boiling point of water varies with elevation above sea level. Once you know the real boiling point in your kitchen, then you should establish the soft ball stage as 25° to 27° higher. Secondly, as soon as the syrup begins to boil, cover the pot for three minutes so that steam will wash back into the syrup any crystals that have formed on the sides of the pot. Uncover the pot, reduce heat, and cook slowly until the syrup reaches the soft ball stage. Avoid letting syrup drip back into the pot from spoons or thermometers.

Remove the pot from the heat as soon as the soft ball stage is reached, and pour at once onto a cold, wet marble slab or platter. Cool thoroughly.

 Begin turning and folding the cooled mass with a scraper or a wooden spoon, until it loses its sheen and begins to look dull and opaque. Knead with your hands to complete this process. All this manipulation produces tiny white crystals, which give a creamy texture.

4. Chill for 24 hours in a tightly covered container.

5. Set the maple cream in the top of a double boiler over hot but not boiling water. Add. a small amount of water and heat slowly until the maple cream is just barely pourable. Then pour into buttered molds and let cool to body temperature before removing and storing in wax paper wrappers in an air-tight container. Alternatively, heat the maple cream only enough so that you can shape it. Turn it out onto a slab or platter. Roll it into 1/2inch diameter tubes. Cool. Slice into 1/4-inch rounds.

Should you overcook the syrup to the point where it cannot be kneaded, simply add a little water, reheat in the double boiler to the soft ball stage, and try again. Maple cream made at home will keep three to four weeks.



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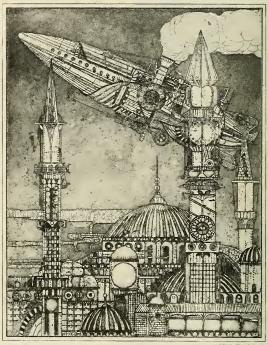
How Easy to See the Future!

If we were to glance over the thousands of years of history of Homo sapiens, we might make the following generalizations: As time passed, the human way of life continually changed. The change has generally resulted from a technological advance-a new tool, a new technique, a new energy source. As each technological advance broadened the base of human technological capacity, further advances became more frequent and were made in a greater number of directions, so that the rate of change has, in the course of history, continually increased.

Until modern times, the rate of change was so slow that the process was unnoticeable in the course of any one person's lifetime. Mankind had the illusion, therefore, that change did not take place. When, in the face of that illusion, a change had clearly taken place, the response was to view it as something that should not have happened—as something that represented a degeneration from the "good old days."

The steadily increasing rate of change reached the stage, about 1800, of becoming clearly visible to many thoughtful individuals. The Industrial Revolution was under way, and those affected by it could detect change in the course of their own lifetimes.

For the first time, people grew to understand that not only was change taking place but that it would continue to take place after their death. It meant there would be changes still greater than a person could live to see, changes that he would never see. This gave rise to a new curiosity—perhaps the first really new curiosity in historic times—that of wondering what life on earth would be like after one was no



CHRISTOPHER J. SPOLLE

longer alive. The literary response to that new curiosity was what we call science fiction. Science fiction can be defined as that branch of literature that deals with the reactions of human beings to changes in sciences and technology.

The reference can be to any changes, of course, and the science fiction writer chooses those that provide him with a dramatic situation out of which he can weave an exciting plot. There is usually no deliberate attempt to predict what will actually happen, but a science fiction writer is a creature of his times, and in trying to imagine a change in science and technology, he is quite likely to base it on those changes he already sees in embryo.

Often this means an extrapolation of the present, an extrapolation that is so clear and obvious as to forecast something that is inevitable. When this happens, the science fiction writer does make a successful prediction. Usually, this astonishes almost everyone, for mankind generally, even today, takes it for granted that things do not change.

Here is an example. As the twentieth century opened, oil was coming into use as a source of energy and, thanks to the internal-combustion engine, was beginning to gain on coal. Now oil, like coal, is a fossil fuel. Even if our entire planet were solid coal and oil, there is only so much of it in the ground-and new supplies are being formed at an entirely trivial rate. If oil and coal are being constantly burned, then someday the natural supply in the ground will be used up. That is not a matter of argument at all; it is inevitable. The only question is when.

Mankind, generally, assuming that since there is oil in the ground today, there will be oil in the ground forever (the doctrine

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of no change) is not concerned with the matter. The science fiction writer, however, avidly seeking out change as a matter of artistic necessity, takes up the possibility of an end of our fossil fuel supply. It then becomes possible for a writer to say: "Coal is the key to metallurgy and oil to transit. When they are done we shall either have built up such a fabric of apparatus, knowledge, and social organization that we shall be able to manage without them . . . or we shall have travelled a long way down the slopes of waste towards extinction. . . . Today, in getting, in distribution, in use, we waste enormously. . . . As we sit there all the world is wasting fuel . . . fantastically.'

That certainly sounds familiar in this year of 1975, but it wasn't said in 1975. The writer was H. G. Wells, the book was Secret Places of the Heart (not even science fiction, strictly speaking), and the year of publication was

Imagine Wells foreseeing the energy crunch half a century before it happened! Well, don't waste your admiration. He saw the obvious and foresaw the inevitable. What is really amazing and frustrating is mankind's habit of refusing to see the obvious and inevitable, until it is there, and then muttering about unforeseen

catastrophes.

The science fiction writer Laurence Manning wrote a story called The Man Who Awoke about a man who invented a potion that would place him in suspended animation for three thousand years. He would then awake and see the world of the future. When he carried this through, he found the world of three thousand years hence was energy poor. They explained to him that this was a result of what they called the Age of Waste. They said, "But for what should we thank the humans of three thousand years ago? For exhausting the coal supplies of the world? For leaving us no petroleum for our chemical factories? For destroying the forests on whole mountain ranges and letting the soil erode into the valleys?"

The story appeared in the March, 1933, issue of *Wonder Stories*, and I read it when it ap-

peared and I had just turned thirteen. Science fiction, everyone said, was "escape literature." Reading it was disgraceful, for it meant turning away from the hard realities of life to a nevernever fantasy land of the impossible.

But who lived in a never-never fantasy land? I, who began worrying about our oil and coal in 1933 as a result of Manning's story? Or the rest of mankind, who as always, were convinced that tomorrow would be exactly like today and who waited for the day when the long lines at the gas, station came before deciding that there might some day be long lines at the gas station.

Yes, science fiction can have its fantasy aspects. I have written stories about galactic empires, about faster-than-light speeds, about intelligent robots that eventually became God, about

SCIENCE FICTION HALL OF FAME, Vol. 1, edited by Robert Silverberg. *Doubleday & Co.*, \$9,95; 558 pp.

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BEFORE THE GOLDEN AGE. edited by Isaac Asimov. Doubleday & Co., \$16.95; 986 pp. THE MAN WHO AWOKE. by Laurence Manning. Ballantine Books, \$1.50; 192 pp.

time-travel. I don't consider that any of these have predictive value; they weren't intended for that. I was just trying to write entertaining stories about the might-be, not at all necessarily about the would-be.

But sometimes.

In the July, 1939, issue of Astounding Science Fiction, there appeared one of my stories. It was called "Trends." and it dealt with the first flight to the moon (silly escape literature, of course). I got all the details childishly and ludicrously wrong, including having it happen ten years later than it really did happen.

Even at the age of nineteen, however, I was aware that all those technological advances in the past that had significantly ruffled the current of human custom had been attacked by impor-

tant segments of the population, who for one reason or another, found it difficult to accept change. It occurred to me, then, that this would surely be true of the development of space flight as well. My story "Trends," therefore, dealt primarily with opposition to space flight. It was, as far as I know, the first description of ideological opposition to mankind's advance into space. Until then, all those who had looked forward to the new development had either ignored the reaction of humanity or had assumed it would be favorable. When there did indeed arise ideological opposition, in the late 1960s, 1 found myself accepting credit as a seer, when I had merely foreseen the inevitable.

Once uranium fission was discovered, a nuclear bomb was an easy extrapolation, and through the years of World War II, the science fiction stories dealing with nuclear bombs nestled as thickly as snowflakes in the pages of the science fiction magazines. One of them, "Deadline," by Cleve Cartmill, which appeared in the March, 1944, issue of Astounding Science Fiction, came so close to the actual facts that both the author and the editor of the magazine were interviewed by intelligence agents. But when the bomb dropped on Hiroshima, the world was astonished.

More remarkable still was a story—"Solution Unsatisfactory," by Anson Macdonald (a pseudonym of Robert A. Heinlein)—that appeared in the May, 1941, issue of Astounding Science Fiction. Written and published before Pearl Harbor, Heinlein described a vast gathering of scientists called together to develop a nuclear weapon. The weapon was invented, used to end World War II, and a nuclear stalemate developed thereafter.

It all made sense, you see, in the light of what was already known in 1940, but who else foresaw it but science fiction writers?

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which means that each day there are 220,000 more mouths to feed. In the course of the last thirty years, during which population has risen by 1,500,000,000, the food supply has managed to keep up, thanks to the spreading use of farm machinery and irrigation pumps, of fertilizers and pesticides, and of an extraordinary run of good weather.

But now weather is taking a turn for the worse, and the energy shortage is slowing the machinery and raising the price of fertilizers and pesticides. The food supply will not be increasing any more; it will probably go down-and with the population going up at a rate of 220,000 per day, isn't it the easiest and surest thing in the world to predict great and spreading famines? Yet whenever I do, I am greeted with amused disbelief. After all, people look around and see no famine today, so why should there be famine tomorrow?

Now let's consider this: If science fiction writers foresee the problems and catastrophes that will come to face mankind, do they also foresee solutions? Not necessarily. Science fiction writers foresee the inevitable, and although problems and catastrophes may be inevitable, solutions are not. Writers are all too often forced to pull solutions out of thin and implausible air—or leave the matter with no solution and end the story in dramatic disaster.

The best way to defeat a catastrophe is to take action to prevent it long before it happens: to conserve the oil and work for alternate sources of energy in time: to consider the international effects of the nuclear bomb before it ever is invented; to lower the birthrate before the population grows dangerously high.

To do that one must foresee the catastrophe in time, but who listens to those who do the foreseeing. "Escape literature," says the world and turns away.

Isaac Asimov is associate professor of biochemistry at Boston University School of Medicine and the author of more than a hundred and fifty books, whose subjects range from science and science fiction to Shakespeare and the Bible.

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the judges laugh). 3. A Chronological Sequence, which may be up to five photographs of an event in nature.

The Rules: We've tried to keep them simple: 1. The competition is open to everyone except, of course, employees of The American Museum of Natural History and their kin, and last year's fourteen winners. 2. Competitors may submit up to three previously unpublished entries in each category. 3. Entries may be transparencies or prints up to 8 by 10 inches, and each must contain the name and address of the photographer, because keeping track of the thousands of entries is one big job. 4. For each entry, we would like to know the camera model used. 5. Include a selfaddressed, stamped envelope, since we do want to return your pictures to you.

The Closing Date: We've tried to keep it short. All entries should be postmarked no later than April 15, 1975—just like your income tax.

The Reward: Our munificence sometimes overwhelms us. Grand Prize is a round trip for two to Rio de Janeiro and the Amazon River. First Prize for each category is \$250. Ten Honorable Mentions will receive \$100 each.

More Rewards: All winning entries will be published in a special, color-crammed issue of *Natural History* and will be exhibited at The American Museum of Natural History.

Some Hitches: The decision of the judges will be final. Natural History acquires the right to publish and exhibit the winning pictures. And Natural History assumes no responsibility for transparencies and prints.

An important point: Pack your beautiful entries carefully and mail them to:

Photography Competition 1975 Natural History Magazine 7 West 77th Street New York, New York 10024

A Final Thought: Good Luck.



Mysterious Tikal

Deep in the Guatemalan jungle lies the ancient city of Tikal, whose very existence baffles archaeologists. Why the Mayans picked that remote location to build a city, how they built it, and why they abandoned it during its height of splendor, are just a few of the questions surrounding this unique place. It's only within the last 30

years that access through the jungle has enabled scientific exploration of 2500-year old Tikal. And it remains one of the most beautiful untouched wonders of the world.

A visit to Tikal is not like any vacation you've ever taken. So come explore for yourself mysterious Tikal. Spend 8 days, 7 nights in Guatemala, including a day in Tikal, for only \$299* from Miami (\$424 from Los Angeles) per person double occupancy. See your travel agent or write:

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Tourist Commission, 929 Sunrise Lane, Ft. Lauderdale, Florida 33304 or 6a Avenida 5-34, Zona 1, Guatemala City, Guatemala, Central America or phone (305) 565-1828.

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- The National Trust Collection

By James Biddle

George Washington was two years old when John Drayton, a member of the King's Council for the Colony of South Carolina, broke ground for a two-storey brick mansion on the Ashley River, 12 miles upstream from Charleston. It stood sturdily through the Revolutionary War and the War of 1812, and is one of the few great Carolina houses to escape the ravages of the Civil War.

And although Drayton Hall is celebrated as one of the great architectural and historical treasures of America, its survival is threatened. Deterioration and vandalism have taken a heavy toll and up to \$2,000,000 is urgently

needed for preservation and the creation of an endowment which will insure the proper long-range support of this priceless land-

If we succeed in raising half this sum, aided by sales of the National Trust Collection of Fine Porcelain Boxes, we can obtain an equal amount of federal funds. Every dollar you give is worth two in our fight to save Drayton Hall. Clearly, your support is of critical importance.

If you join us in this cause, you will be invited to attend a dedication of Drayton Hall next April. A Southern country breakfast will be provided at the Plantation, followed by a reception

at Russell House, headquarters of the Historic Charleston Foundation and one of the most beautiful early 19th century houses in America. There we will celebrate the rescue of Drayton Hall and mark the completion of our twenty-fifth year as the only non-governmental organization chartered by Congress to safeguard America's cultural and historical heritage.

The invitation list will include our five Honorary Members, Mrs. Nixon, Mrs. Johnson, Mrs. Onassis, Mrs. Eisenhower and Mrs. Truman. The Secretary of the Interior and members of Congress will be invited, as will eminent architects, historians and preservationists

A specially commissioned medallion will be struck to honor this significant milestone in the history of preservation, and each subscriber will receive a serially numbered copy in pure silver, or in bronze.

Each box is different in shape, made from models over 100 years old and is decorated in exquisite detail from original oils, watercolors, and design motifs found within our National Trust properties. The artists who inspired these designs include Edward Savage (1789), John Robert Murray (1824), Alexander Jackson Davis (1838), and Currier & Ives (1875).

Of course, fine art cannot be transferred directly to porcelain but must be repainted for the medium by highly skilled artists. Two were selected for this delicate assignment, each with 25 years of experience. Both have been named "Best Worker of France", an extraordinary award given but once every

three years to a handful of workers in the entire nation.

The secret of making porcelain was guarded by its Chinese originators for 1200 years. It was not until 1709 that an alchemist in Meissen discovered the Chinese formula, but he kept it only a decade. During this short span, German artisans developed porcelain as an art form, and when other European centers learned the secret, they contributed to the state of the art.

Paris was one of these cen-Drayton Hall Serially numbered medallion celebrating the rescue ters, and outstanding among its of Drayton Hall and the Twenty-Fifth Anniversary of the National many factories was Porcelaine de Paris, established by Jean Baptiste Locre in 1773 - the year of our Boston Tea Party.

It has been, since 1860, the sole surviving porcelain factory in the City of Paris.

The Prospect of Appreciation

There is no guarantee that these boxes will increase in value. However, it has become abundantly clear in recent years that the greatest increase among collectors' items is



The National Trust Collection of Fine Porcelain Boxes celebrates some of the historic properties which the Trust preserves for public benefit: Cliveden, Woodlawn, Shadowson-the-Teche, Lyndhurst, and Decatur House. We selected for this demanding project the finest of the few craftsmen in the world capable of meeting our standards: the famous and venerable Porcelaine de Paris.

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James Biddle, President of the National Trust for Historic Preservation, was Curator of the American Wing of the Metropolitan Museum of Art.







Fine Porcelain Boxes 🚄

obtained by limited editions with specific characteristics:

- · The issue must be officially sanctioned. · The quality of materials used should
- be, simply, the best obtainable. The artistic merit must be exceptional.
- · The craftsmanship must be impeccable.
- The edition must be strictly limited.
- It is my opinion that these boxes meet

our exacting requirements in every respect. Whether you wish to purchase them for aesthetic, charitable, or investment reasons — or all three — we commend them to your consideration.

For your information, antique porcelain boxes, especially those from the 18th century, are bringing extremely high prices. In the past five years, prices have more than tripled. At one recent Sotheby Parke-Bernet auction, a 1745 gold-mounted porcelain box from Meissen fetched \$2,400, and at another auction, 11 boxes were knocked down at prices ranging from \$175 to \$30,000 each.

A Very Limited Offering

The National Trust Collection is strictly limited to 2,500 sets. Each one of the five boxes in every set is serially numbered. Orders will be filled in the exact sequence in which they are received, one set per subscriber.

The first set will be presented to the Smithsonian Institution for its permanent collection. The last set will remain on display in our Decatur House headquarters. The remaining 2,498 are available at \$600 the set. Upon completion of sale, the litho stones used to prepare the series will be defaced, thus assuring protection to all subscribers for all time.

If you agree that these boxes are outstanding, that prospects for their appreciation are indeed bright, and that our work to save Drayton Hall and preserve America's heritage is worthy of your support - then I urge you to act promptly.

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ceipt of your Collection to make your own independent appraisal and decide if you wish to keep it. If you decide against the Collection, simply return it insured. Your payment will be refunded in full and there will be no further obligation.

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And, of course, you will be a guest of honor next April at Drayton Hall when we salute our first 25 years and celebrate the rescue of this magnificent property. It will be a memorable gathering.

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Authors



While gathering material on the language and culture of the Wintu Indians for a U.S. Forest Service educational project, Peter M. Knudtson interviewed several elderly members of this California tribe, among them Flora Jones, the last practicing Wintu shaman. Over the past three years, he has visited her regularly, recording details of her culture for a book he is preparing. He helped Flora obtain permission to conduct healing ceremonies and gather herbs on traditional Wintu lands now under the jurisdiction of the Forest Service. Knudtson, who received his master's degree in biology from Humboldt State University, is also interested in the social behavior of mammals. His article, "Birth of a Harbor Seal," appeared in the May, 1974, issue of Natural History.

Currently a visiting research professor at the University of Bielefeld in West Germany, Klaus-Friedrich Koch took his Ph.D. in anthropology from the University of California at Berkeley and taught the subject at Harvard University from 1967 to 1974. He has spent many months of field work in New Guinea and Fiji and is at present studying social organization and law in Arab culture. Koch is also planning to do field research on the legal structure of kinship in the Arabian Peninsula. His numerous publications include a previous article for Natural History, "Cannibalistic Revenge in Jalé Warfare" (February, 1970).

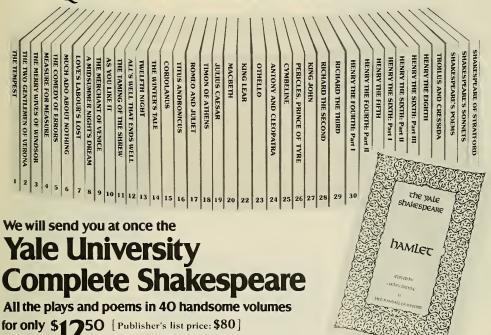




Soraya Altorki, the first Saudi Arabian woman to obtain a Ph.D. (in anthropology from the University of California at Berkeley), teaches social sciences at King Abd al-Aziz University in Jidda. She has done field work on family organization

and domestic groups in her own country and was a fellow at the Center for Middle Eastern Studies at Harvard University. Her research plans include an analysis of the position of women in changing Arab culture.

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At the age of ten, Robert Michael Pyle became interested in cynthia moths through a photograph of this beautiful insect. Later, a collector gave him a specimen, which, Pyle says, "cemented my fascination." Now studying at the Yale University School of Forestry and Environmental Studies. Pyle is the founder and director of the Xerces Society, an international organization for the conservation of insect populations. When not involved with the politics and ecology of moth and butterfly conservation, the subject of his doctoral dissertation, Pyle likes to throw the discus and watch birds. Andrew Skolnick. a nature and science photographer based in New Haven, Connecticut. one day noticed cynthia moth cocoons in a railroad yard and began photographing them. Curious about the moths, he sought out Pyle and interested him in writing an article on this species.



For the past twenty years, Wilhemina F. Jashemski has been commuting between the University of Maryland, where she is professor of ancient history, and the ruins of Pompeii, where she directs the University's excavations, a project funded by the National Endowment for the Humanities. Believing-contrary to widely held opinion-that much of the ancient city was planted in gardens, Jashemski has concentrated her research on subsoil excavations. Her belief has been confirmed by the finding of root cavities at most work sites. She is currently finishing a book, The Gardens of Pompeii, Herculaneum, and Stabiae.





As a biologist working with the Australian Commonwealth Scientific and Industrial Research Organization's Division of Wildlife Research in Canberra. L. Wavne Braithwaite has done an intensive study of the distribution of waterfowl in Australia. He has been most interested in the movement of ducks and geese during flood periods and in the ability of certain species to adapt to the country's typically arid climate. Braithwaite has specialized in the distribution of the black swan and has traced the dramatic expansion of its range from the southeast to the north as more and more rivers are dammed, thus insuring permanent water sources.



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Flora, Shaman of the Wintu

by Peter H. Knudtson

Remembrance of traditions past by the last healer of a California tribe

Once a vital and flourishing people, the Wintu of northern California were the northernmost dialect group of the once vast Wintun Indian nation. Occupying a territory that sprawled along the western bank of the Sacramento River from the vicinity of Mount Shasta southward to San Francisco Bay, the Wintun numbered at least 12,000 people before 1870. But a hundred years of racial violence, disease, poverty, emigration, and intermarriage have taken their toll, leaving only 1,165 Wintun, according to the census of 1970.

Before their culture was devastated, the Wintu traditionally initiated shamans into their roles as tribal healers and spiritual guides through elaborate communal ceremonies.

The rite began in the evening, with the shamans and shaman candidates dancing naked around a manzanita-wood fire and singing to invoke the spirits. A whistling sound above the smoke hole of the earth lodge signaled the arrival of the spirits. If a spirit found a candidate acceptable, it entered his body. When this happened, the novice's behavior became frenzied: his body jerked convulsively, saliva poured from his lips, and sometimes blood flowed from his mouth and nostrils. Finally, he fell to the ground and was carried by the older shamans to one side of the lodge, where he was carefully watched over and sung for. Each man or woman thus called upon by the spirits was then recognized by his tribesmen as an individual who possessed a potent rapport with the world of spirits—a world that the shaman would reenter during the trance of healing séances countless times in the future.

Today, memory of language or traditions is rare among the Wintu and only one acknowledged shaman remains-an elderly, vibrant woman named Flora Jones. Living on a modest ranch located within former tribal boundaries, Flora (or Pui-lu-limet, "Eastern-Flower-Woman," by her Wintu name) remains an active practitioner of the ancient healing arts of her people. She still conducts shamanistic séances and administers traditional herbal medicines to patients of her own and neighboring tribes.

I first met Flora in 1972. As our friendship grew, we would spend hours discussing her healing activities, sometimes visiting sacred doctoring places along the McCloud River near her home. In the beginning Flora voiced misgivings about my questions, saying at one point, "Of course the spirits that I doctor don't like the white people." Then she would add, "But I have been praying for you since I knew you. I tell the spirits that you are my child and they must accept you. And that I have looked you over thoroughly and you mean no

Although her reluctance to discuss certain matters proved frustrating, it came as no surprise. Her reticence had been voiced by another Wintu shaman in a dream song recorded by ethnographers more than forty years ago:

When Red Cane [white man] comes
We Wintu shall forget our songs.

Because her people's culture has undergone catastrophic changes in the last century, Flora's practices cannot be viewed as a crystalline record of Wintu shamanistic arts; rather they represent an amalgam of modern practices and traditional spiritual doctoring. Nonetheless, the traditional elements remain, and her story bears a special importance at this time, for there is no apparent successor to her sacred office. By her own admission, Flora will probably be the last of the Wintu shamans.

Flora calls herself an Indian doctor. Most anthropologists, however, would call her a shaman since the diagnostic feature of a shaman is the capacity to go into trance-the ecstatic state in which the supernatural world of tribal spirits is directly experienced. Shamans often describe the ecstatic trance in terms of a journey of the soul. Wintu accounts suggest a more passive role for the shaman. Flora explains, "The spirits use me for just a tool-something to get into to tell the people what is going to happen and what they can do." Here a shaman's powers of prophecy and clairvoyance seem to arise, not from the wanderings of the soul, but from the omniscience of certain mobile helping spirits, as well as the omnipresent



guiding force of the Wintu creator-god, Olelbes.

Wintu helping spirits take many forms—they may be spiritual forces residing in sacred places or celestial bodies, the spirits of animals, or the souls of departed relatives, among others. Flora's own pantheon of spirit helpers contains representatives of each, acquired through long years of doctoring experience, and each is endowed with its own personality and usefulness.

She describes the suckerfish spirit as a trickster, a mischievous polyglot not to be trusted during a trance. Another, the black wolf spirit, projects a hostile character and appears most often during times of deep distress. Others-a star spirit, a moon spirit, a mountain spirit, the soul of an ancestral shaman-may appear to her during a séance as well. When several spirits enter simultaneously, engaging in animated discussion during a trance, the mountain spirit acts as leader and spokesman.

Occasionally, I would ask Flora to list her helping spirits, only to discover that the "list" grew longer with each attempt as she recalled still other sacred mountains or springs or rock formations. The spiritual world of the Wintu, it soon became apparent, is not easily circumscribed. A suggestion that she try to sketch one of her spirits drew a burst of friendly laughter. White people did not seem to understand, she told me, that the spirits could not be drawn, for their appearance was fleeting, beyond description.

Although Flora became a shaman at a time when the cere-

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mony of the communal spiritquest, or "doctor's dance," scribed above had been lost to the Wintu, her initiation experiences revealed features common to traditional shamanism in both her own and other cultures.

Flora, an adolescent at the time, was attending a federal school in San Francisco when she first experienced the vivid dreams that eventually led her home to become a shaman. These dreams confused and terrified her but they also challenged her to resolve the dilemma of living in a world that was to her both Wintu and white.

From the beginning her life was a paradox. Born in 1909 of racially mixed parentage (her great-grandfather was the last great chief of the McCloud River Wintu), she was baptized a Methodist yet accepted the reality of childhood encounters with tribal animal spirits. Although formally educated in government schools, she was reared by a mother who spoke Wintu and often relied upon Wintu shamans to maintain her daughter's health. As a young girl, Flora was lured by fantasies of a career as a Hollywood actress, yet she shot her first deer at the age of ten and, following tribal tradition, abstained from the eating of this first flesh.

At the age of seventeen came the climactic event of her calling-her first trance. She was engrossed in a card game with friends when, without warning, her ears were filled with a ringing sound and a burning pain.

"It was like a hot bullet going through my ear," she recalled. "The pain went through me and I passed out for four days." Years later she viewed this traumatic experience as her first ecstatic encounter with a helping spirit-the star spirit.

She awoke from her prolonged unconsciousness singing. With her were four older Wintu shamans, who in a manner reminiscent of the traditional initiation ceremony, sang and cared for her, administering medicine and later taking her to sacred places to pray. In the days that followed, her helping spirit taught her doctoring songs and tutored her in the healing arts of the shaman. Finding her acceptable in their own trances, the elder shamans established her as a shaman in her own right, although she did not begin doctoring until years later. By singing songs, visiting sacred places, and entering trances, Flora found that a new calm had settled over her. No longer, as in years past, was she beset by mental turmoil and sickness, by the contradictions of her upbringing, and by self-doubt; no longer were "the spirits taking her to the mountains.

Some of the most illuminating conversations I have had with Flora were held at a sacred place where she often carried out séances. Located in a shady stand of black oak trees, it was, she said, the former site of an earth lodge, or hlut, where Wintu doctors had once healed the sick. At such times, cheered by the familiar surroundings, Flora talked at length of her life as a doctor-her voice sometimes low and resonant as she spoke in careful phrases, sometimes rising to an excited pitch as she described a particular dream or premonition.

She told me of the five kinds of Wintu doctors. Each had his own area of expertise but lacked the high degree of specialization attained by shamans of certain neighboring tribes of California Indians. The first two, the dreamers and the singers, were shamans possessing powers of clairvoyance not associated with curing. Tracer doctors were adept at locating lost objects or souls. And sucking and healing doctors were primarily active in the realm of healing.

Although each of the five types worked through a trancelike state, the sucking doctors were traditionally the most powerful and highly regarded by tribesmen. They cured by extracting minute pathogenic spirit-missiles, or "pains." They removed the pains by sucking while in a trance—a procedure that presumably affected local blood flow as well.

Flora considers herself a healing doctor, diagnosing illnesses with her hands during an ecstatic healing séance. But like many shamans she has displayed elements of more than one specialty. For example, as a healing shaman, she has sucked pains from

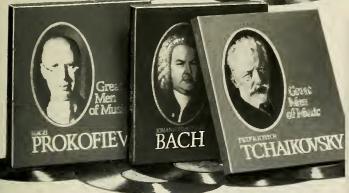
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certain patients, but like a tracer doctor, she predicted the location of a missing corpse on a nearby river.

Her séances usually take place in the company of a traditional assistant, or "interpreter," the patient, and various friends and family members. Despite her willingness for me to do so, I have not yet witnessed one of Flora's doctoring ceremonies and must rely on her accounts, as well as tape recordings of some of her séances, for my descriptions.

Oddly enough, the tapes were the fruits of Flora's own recording efforts, for she had on occasion been forced to use a tape recorder in place of the elderly man who usually served as her interpreter. By replaying the tapes she was able to penetrate the amnesia that inevitably follows her trances—the tapes acted as a surrogate interpreter, revealing the supernatural dialogue that had taken place. At first the mechanical aid offended her spirit-helpers, but under the circumstances they were quite soon mollified.

Once assembled, the participants in a séance join the shaman in summoning the helping spirits by singing the appropriate Wintu songs. (One such song, according to Flora, describes a shaman's search for a path taken by the souls of the dead to heaven and his conversations with trees and flowers along the way.) Periodically, the shaman accepts a pipe of tobacco from the interpreter, inhales deeply, then resumes singing. Traditionally, shamans used a species of wild tobacco (Nicotiana bigelovii) to enter a trance; today, commercial tobacco must suffice.

The arrival of the spirit-helpers is marked by the shaman's sharp inhalation; the group falls silent as the spirits begin to speak through the shaman's voice, offering advice or prophecies and sometimes quarreling or joking among themselves.

The shaman drinks clear water, then a solution of acorn water from a small container—an offering to the helping spirits. With the diagnostic powers of the spirit-helpers acting through her hands, she begins to move her fingers carefully across the patient's body, sensing unseen internal injuries or abnormalities.

"I feel for the sores, the aches, and the pains. When I put my hand over the body I can feel every little muscle and every little vein. I can feel the soreness. It hurts me. If they have heart trouble, my heart just beats. Any place they are hurting, I hurt. I become a part of their body."

If the spirits detect the source of the sickness, they prescribe for the patient's care, speaking through the shaman. Remedies may be offered for both physical and psychological ills and often include traditional herbal medicines, which Flora meticulously collects and stores.

Upon awakening from the trance, the shaman learns of the spiritual diagnosis from the interpreter and proceeds to treat the patient accordingly. In the past, a patient's family would present the shaman with a tiny, handmade basket of characteristic striped design following a successful treatment. Now the transaction usually involves money and takes place regardless of the outcome of the therapy.

Only in the most dire cases, when a patient is unconscious and death imminent, does Flora perform the Soul Dance—a final attempt to recapture the victim's wandering soul. This ritual is performed at midnight. As the shaman dances to the rhythmic beating of sticks she waves a staff bearing a miniature basket in which to catch the lost soul. If the shaman's search is successful, the soul is brought back to its owner and placed over his heart, its natural resting place.

When not in use, the staff and other shamanistic regalia are kept out of sight, often in a special hiding place, and treated with great respect. They include sacred "yellow hammer" feathers, which can be used to "pull evil dreams" from a person, and a wooden pipe possessing spiritual powers that can be consulted for advice. In addition, Wintu shamans have included among their doctoring paraphernalia rattlesnake rattles, rattles made from cocoons, and the hollow leg bones of birds (to contain extracted pains).

At one time, the mere presence of a white man at a séance was sufficient to disturb Flora's trance. Gradually, and with apparent reluctance, her helping spirits have come to accept and diagnose white patients as well as Indians.

"Nowadays," Flora stated solemnly, "we have to live almost half in the white man's way and half in my own way. I will never forget my own way, but I have to steer myself with the white ways. The spirits understand that. . . . I was told by the spiritual one time when I was doctoring that I must help my white brothers as well, if I am to be a thoroughly spiritual doctor."

Treatment of whites, however, seems to demand different techniques. Diagnosis takes place without an interpreter and involves only a brief trance. Like some sort of transient X-ray image, the trance permits Flora to visually scan the patient's internal organs for the source of his discomforts.

Wintu shamans traditionally ascribed three possible causes to most diseases. The first and most commonly encountered were the yapaitu dokos-minute disease-objects, or pains, which might be sent by an offended spirit or perhaps a sorcerer and which were often detectable in the blood. The origins of such an etiology are obscure, but it is interesting that the naturalist C. Hart Merriam reported that Wintu shamans once prepared and surreptitiously threw tiny poison darts at victims. Diseases may also arise through spirit possession, especially in situations involving the violation of a particular taboo. Or a person's soul may be lostreleased during a period of unconsciousness or stolen by an evil spirit.

Flora attributes most diseases to some form of self-inflicted stress, emotional or physical, and seldom mentions traditional pathology. Although she frequently resorts to the use of medicinal herbs, much of her treatment lies in preventive medicine—giving advice on personal attitudes, care of the body, and proper nutrition, for example. She is critical of processed foods and refuses to drink tap water, preferring instead to journey several miles to fill containers with water from sa-

cred springs. Her diet, too, is restricted, partly in deference to traditional food taboos established by her spirit-helpers. She maintains that the discipline imposed by such a regimen, along with advancing age, tends to strengthen the powers of a shaman.

Some diseases, unless detected at an early stage, are considered beyond the healing powers of a shaman. Most of these are categorized as "white man's diseases"-ulcers, cirrhosis of the liver, and certain cancers, for instance. Actually, according to early-twentieth-century ethnomedical studies, numerous other diseases were introduced to California Indian populations by Europeans. These include smallpox, tuberculosis, cholera, typhoid, scarlet fever, measles, whooping cough, syphillis, and gonorrhea. If true, such claims may add deadly irony to the Wintus' choice of the words yapaitu wintun, sometimes translated "poison people," to describe the white intruders who were often disease vectors as well.

Prophetic dreams occupy an important place in Flora's activities and have been an important factor in the formation of her world view. She is convinced through her dreams, for example, of the impending destruction of the world-a feeling reflected in the following statement: "The Indians are going to get down very low [in numbers], but this world is getting so near to the end. The white people are getting too close to the moon and the sun. The white people are causing the world to end."

The prophecy of a world corrupted by whites and on the verge of catastrophe is not a novel one among Wintu shamans. Faced with the erosion of their culture, the Wintu have openly entertained such thoughts since at least 1870, when the revivalistic Ghost Dance Movement, with its dreams of the dead and its predictions of the world's end swept through their territory.

In response to some of her dreams, Flora has recently joined others in trying to generate a spiritual renaissance among people of her own and other tribes. Speaking of her sacred ob-



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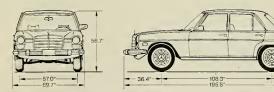
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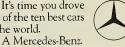
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ligations as a shaman, she told me, "This is what the spirit tells me—get my people together. Get them to believe because if you don't, they are going to go wild. They are going to kill one another. Whoever has sacred places must wake them up, the same as I am doing here—to keep my old world within my heart and with the spiritual. For them to help me and for me to help my people."

In an attempt to "wake up" certain Wintu sacred places and revitalize her doctoring activities, Flora in 1973 approached the U.S. Forest Service, which now controls much of former Wintu lands, for permission to carry out doctoring ceremonies on public lands. Cautiously cooperative. the Forest Service advised that "by means of this letter you are hereby authorized to utilize approximately 1 acre of land . . . to carry out your Indian doctor practices. This does not authorize the violation of any County, State or Federal Laws.

Flora has also conducted a special prayer ceremony on a mountaintop near her home. Obeying dreams in which helping spirits appeared and provided instructions, she entered a trance and, waving her shaman's staff toward the four directions of the compass, uttered prayers and advice from the spirits that speak through her.

Once, when I was photographing Flora at one of her sacred places, she startled me by asking if I sensed the spirits around me. They had been examining me, she said, and in the process she had seen my face disappear for an instant as I sighted through the camera. "Were you dormant?" she asked intently.

From the beginning, my relationship with Flora was based upon both my curiosity and my skepticism—the latter. I knew, blinded me to much of what she tried to communicate to me. I felt compelled to reduce her shaman's world to what I believed must be its scientific roots. Yes, I was forced to admit, I was dormant: I had not sensed the spirits about me.

Many attempts have been made in the literature of anthropology to suggest a physiological or psychopathic basis to shamanism. Inevitably, this attitude seems offensive or foolish to those Indians who believe in the old ways. Some researchers have pointed to a constitutional predisposition among certain individuals to become shamans. Others have emphasized the role of hallucinogens, while still others have hypothesized such exogenous factors as environmental sensory deprivation (among Arctic peoples, for example), or such endogeneous ones as brain lesions and epilepsy.

As one possible explanation, epilepsy, in particular, has offered intriguing possibilities in certain cases. It has been implicated in studies of shamanism from widely divergent cultures, with reports of seizures and other epileptoid features. Such features are discernible in Wintu shamanism as well. Convulsive seizures frequently accompany the initiations of shamans. There are the perplexing and strikingly uniform reports by shamans of sounds that often precede their trances. "Whizzing," "buzzing," or "ringing" in the ear, sometimes accompanied by abdominal pains, appear repeatedly in their descriptions of the auralike premonition of a trance.

I once asked Flora if the sensations she experienced while entering a trance might not be akin to what an epileptic feels. The term epileptic did not surprise her; she often included modern medical terms in our conversations. She answered directly, "It does not necessarily have to work through epilepsy." Then pausing, she added, "The spiritual acts in many ways."

Those ways remain largely the province of the shaman's rich internal world—invisible to an analytical mentality. That the shaman is possessed of considerable personal strength and real healing power—whether in the realm of herbal medicine, psychosomatic medicine, or his own psychotherapy—there is little doubt

Perhaps those of us who fail to fully comprehend the techniques of ecstatic healing are, as Flora suggested, simply suffering a spiritual dormancy. Such people, she says, are deserving of her sorrow, for they live out their lives "with clouds in front of them."

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Ponce de Leon's search for the fountain of youth continues in retirement villas of the sunshine state he discovered. Chinese alchemists once searched for the drug of deathlessness by allying the incorruptibility of flesh with the permanence of gold. How many of us would still make Faust's pact with the devil in exchange for perpetual life?

But our literature also records the potential problems of immortality. Wordsworth, in his famous ode, argued that childhood's bright vision of "splendor in the grass, of glory in the flower" can never be recaptured-though he counseled us to "grieve not, rather find strength in what remains behind." Aldous Huxley once devoted a novel-After Many a Summer Dies the Swanto illustrating eternity's mixed blessing. With the consummate arrogance that only an American millionaire could display, Jo Stoyte sets out to purchase his immortality. Stoyte's hired scientist, Dr. Obispo, discovers that the fifth earl of Gonister has, by daily ingestion of carp guts, prolonged his life well beyond 200 years. They rush to England, break into the earl's guarded residence, and discover-to Stoyte's horror and Obispo's profound amusement-that the earl and his lover have grown up into apes. The horrid truth of our origin is out: We evolved by retaining the youthful features of our ancestors, a process known technically as neoteny (literally, "holding youth").

"A foetal ape that's had time to grow up," Dr. Obispo managed at last to say. "It's too good!" Laughter overtook him

again. . . . Mr. Stoyte seized him by the shoulder and violently shook him. . . . "What's happened to them?" "Just time," said Dr. Obispo airily. . . . the foetal anthropoid was able to come to maturity. . . . without moving from where he was sitting, the Fifth Earl urinated on the floor.

Aldous Huxley got his theme from the "fetalization theory" proposed in the 1920s by the Dutch anatomist Louis Bolk (and probably transmitted to him by brother Julian, who had been doing some important research on delayed metamorphosis in amphibians). Bolk based his idea on the impressive list of features that we hold in common with the juvenile-but not the adultstages of other primates or of mammals in general. The list includes, among more than twenty important characters, the following:

1. Our rounded, bulbous cranium-house of our large brain. Embryonic apes and monkeys have a similar cranium, but the brain grows so much more slowly than the rest of the body (see my columns of February, 1974, and January, 1975) that the cranial vault becomes lower and relatively smaller in adults. Our brain itself probably achieved large size by the retention of rapid fetal growth rates.

2. Our "juvenile" face-straight profile, small jaws and teeth, weak brow ridges. The equally small jaws of juvenile apes grow relatively faster than the rest of the skull, forming a pronounced muzzle in adults.

3. Position of the foramen magnum-the hole in our skull base from which the spinal cord emerges. As in the embryos of most mammals, our foramen magnum lies underneath our skull, pointing downward. Our skull is mounted on top of our backbone, and we look forward when standing upright. In other mammals, this embryonic location changes as the foramen moves to a position behind the skull pointing backward. This is suited for four-footed life since the head is now mounted in front of the vertebrae and the eyes are directed forward. The three morphological features most often cited as marks of mankind are our large brain, our small jaws and our upright posture. The retention of juvenile features may have played an important role in

evolving all of them.

4. Late closure of the skull sutures and other marks of delayed calcification of the skeleton. Babies have a large "soft spot," and the sutures between our skull bones do not fully close until well after adulthood. Thus, our brain can continue its pronounced postnatal expansion. (In most other mammals, the brain is nearly complete at birth and the skull is fully ossified.) A leading primate anatomist has remarked: "Though man grows in utero to larger sizes than any other primate, his skeletal maturation has progressed less at birth than in any monkey or ape for which relevant information has become available." Only in man are the ends of long bones and digits still entirely cartilaginous at birth.

5. Ventral pointing of the vaginal canal in women. We copulate most comfortably face to face because we are built to do it that way. The vaginal canal also points forward in mammalian embryos, but it rotates back in adults, and males mount from the rear.

6. Our strong, unrotated, nonopposable big toe. The big toe of most primates begins as ours, in conjunction with its neighbors, but it rotates to the side and opposes the others for efficient grasping. By retaining a juvenile trait to yield a stronger foot for walking, our upright posture is enhanced.



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Bolk's list was impressive (this is only a small part of it), but he tied it to a theory that doomed his observations to oblivion and gave Aldous Huxley his anti-Faustian metaphor. Bolk proposed that we evolved by an alteration in our hormonal balance that delayed development as a whole. He wrote:

If I wished to express the basic principle of my ideas in a somewhat strongly worded sentence, I would say that man, in his bodily development, is a primate fetus that has become sexually mature.

Or, to quote Aldous Huxley again:

There's a kind of glandular equilibrium. . . . Then a mutation comes along and knocks it sideways. You get a new equilibrium that happens to retard the developmental rate. You grow up; but you do it so slowly that you're dead before you've stopped being like your great-great-grandfather's fetus.

Bolk did not shrink from the obvious implication. If we owe all our distinctive features to a hormonal brake on development, then that brake might be easily released: "You will note," writes Bolk, "that a number of what we might call pithecoid features dwell within us in latent condition, waiting only for the falling away of the retarding forces to become active again."

What a tenuous position for the crown of creation! An ape arrested in its development, holding the spark of divinity only through a chemical brake placed upon its glandular development.

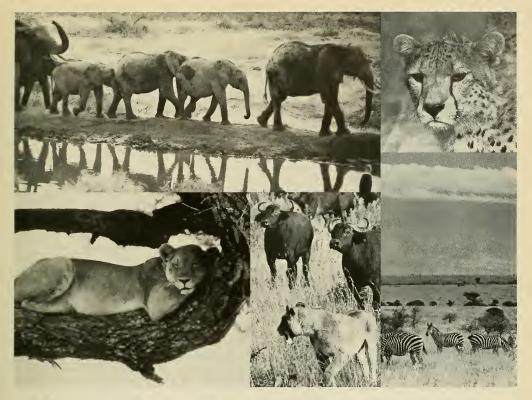
Bolk's mechanism never won much support, but it began to grow in absurdity as modern Darwinian theory became established during the 1930s.

How could a simple hormonal change produce such a complicated morphological response? Not all our features are retarded (long legs, for example), and those that are display varying degrees of delay. Organs evolve separately in response to differing adaptive requirements—a concept we call mosaic evolution. Bolk, as a vitalist, had never considered the adaptive significance of our

retarded characters. Unfortunately, Bolk's excellent observations were buried under the barrage of justified criticism for his fanciful mechanism. The theory of human neoteny is now usually relegated to a paragraph or two in anthropology textbooks. Yet I believe that it is fundamentally correct; an essential, if not dominant, theme in human evolution. But how can we rescue Bolk's observations from his theory?

If we must base our argument upon the list of neotenic features, then we are lost. The concept of mosaic evolution dictates that organs will evolve in different ways to meet varying selective pressures. Supporters of neoteny list their features, opponents tote theirs, and a stalemate is quickly reached. Who is to say which features are "more fundamental"? For example, one recent supporter of neoteny has written: "Most animals show retardation in some features, acceleration in others. . . . On balance, I think that in man, as compared with other primates, the slowing down far outweighs the speeding up." But a detractor proclaims: "The neotenic characters . . . are secondary consequences of the nonneotenic key characters." The validation of neoteny as fundamental requires more than an impressive list of retarded characters; it must be justified as an expected result of processes acting in human evolution.

The notion of neoteny achieved its initial fame as a way of opposing the theory of recapitulation, which had dominated evolutionary biology during the late nineteenth century. The theory of recapitulation proclaimed that animals repeated the adult stages of their ancestors during their own embryonic and postnatal growth-ontogeny recapitulates phylogeny, in that mystical phrase we all learned in high school biology. Our embryonic gill slits, for example, were said to represent the adult fish from which we descended. If recapitulation were the general rulewhich it is not-then features must be accelerated during evolutionary history, for adult characters of ancestors can become the juvenile stages of descendants only if their appearance is



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Burleigh Brooks Optics, Inc. 44 Burlews Ct., Hackensack, N.J. 07601 speeded up. But neotenic characters are retarded since juvenile features of ancestors are delayed to appear in the adult stages of descendants. Thus, there is a general correspondence between accelerated development and recapitulation on the one hand and delayed development and neoteny on the other. If we can demonstrate a general delay of development in human evolution, then neoteny in key features becomes an expectation, not just an empirical listing.

I do not think that retardation can be denied as a basic event in human evolution. First of all, primates in general are retarded with respect to most other mammals. They live longer and mature more slowly than other mammals of comparable body size. The trend continues throughout primate evolution. Apes are generally larger, mature more slowly, and live longer than monkeys and prosimians. The course and tempo of our lives has slowed up even more dramatically. Our gestation period is only slightly longer than that of apes, but our babies are born much heavier-presumably because we retain our rapid fetal growth rates. I have already commented on the delay in ossification of our bones. Our teeth erupt later, we mature later, and we live longer. Many of our systems continue to grow long after comparable organs have ceased in other primates. At birth, the brain of a rhesus monkey is 65 percent of its final size, a chimpanzee's is 40.5 percent, but we attain only 23 percent. Chimps and gorillas reach 70 percent of final brain size early in their first year; we do not attain this value until early in our third year. W.M. Krogman, our leading expert in child growth, has written: "Man has absolutely the most protracted period of infancy, childhood and juvenility of all forms of life, i.e., he is a neotenous or long-growing animal. Nearly thirty percent of his entire life-span is devoted to growing."

This temporal slowdown in our development does not guarantee that we will retain juvenile proportions as adults. But since neoteny and retarded development are generally linked, retardation

does provide a mechanism for the easy retention of any juvenile feature that suits the adult life style of descendants. In fact, juvenile features are a storehouse of potential adaptations for descendants, and they can be utilized easily if development is strongly retarded in time. In our case, the "availability" of juvenile features clearly controlled the pathway to many of our distinctive adaptations.

But what is the adaptive significance of retarded development itself? The answer to this question probably lies in our social evolution. We are preeminently a learning animal. We are not particularly strong, particularly swift, or particularly well designed; we do not reproduce rapidly. Our advantage lies in our brain, with its remarkable capacity for learning by experience. To enhance our learning, we have lengthened our childhood by delaying sexual maturation with its adolescent yearning for independence. Our children are tied for longer periods to their parents, thus increasing their own time of learning and strengthening family ties as

This argument is an old one, but it wears well. John Locke (1689) praised our lengthy childhood for keeping parents together: "Wherein one cannot but admire the wisdom of the great Creator who . . . hath made it necessary that society of man and wife should be more lasting than that of male and female among other creatures, that so their industry might be encouraged, and their interest better united, to make provision and lay up goods for their common issue." But Alexander Pope (1735) said it even better, and in heroic couplets to

The beast and bird their common charge attend

The mothers nurse it, and the sires defend

The young dismissed, to wander earth and air,

There stops the instinct, and there ends the care.

A longer care man's helpless kind demands,

That longer care contracts more lasting bands.

Stephen Jay Gould teaches geology at Harvard University.



The Great Gathering at Arafat

by Soraya Altorki and Klaus-Friedrich Koch

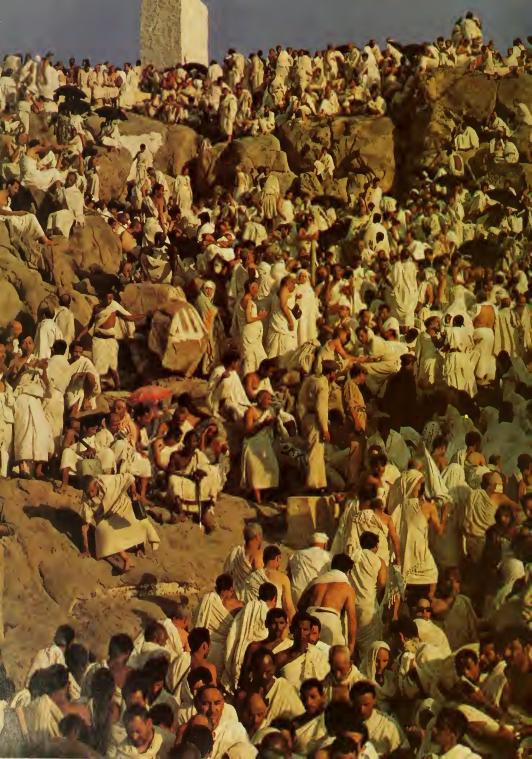
Only at the climax of the annual Muslim pilgrimage can one hear so many people, from so many countries, speaking so many languages

Every year, during the last month of the Islamic lunar calendar, Muslims from all over the world congregate at the Mount of Mercy. This small, rocky hill rises on the arid plain of Arafat about twelve miles east of the holy city of Mecca in Saudi Arabia. A legend tells that it was at Arafat that Adam first "knew" Eve. Here the angel Gabriel had led them together again after many years of separate wandering upon the earth following their expulsion from paradise. At Arafat the Prophet Muhammad received the last of the revelations that make up the 114 suras, or chapters, of the Koran.

In December, 1974, almost one million Muslims from countries around the world made their pilgrimage to these holy grounds. Another half-million came from within Arabia. Pilgrims came in crowded trucks and buses from as far as Turkey and Iran. Many came on ships from the distant countries of Asia and Africa, arriving at Jidda, on the Red Sea, some forty-five miles west of Mecca. Thousands drove their own cars, some from as far away as Yugoslavia. And hundreds of thousands from around the globe arrived in Jidda in chartered planes. Day after day, long lines of cars, trucks, and buses brought the pilgrims from Jidda to Mecca and onward to Arafat. The divided highway carrying this traffic follows the old caravan route, which earlier pilgrims traveled on camelback. In those times many Muslims from eastern Asia









Dedicating their thoughts to Allah, a group of Muslims pray (foreground). Behind them a multitude of worshipers swarms over the sacred Mount of Mercy.

would undertake a two- or three-year journey on foot to reach Arafat. Even today many pilgrims hike from Mecca to Arafat, although many others make the trip in chauffeured, air-conditioned limousines.

The tribes of ancient Arabia visited the Kaaba and other sacred shrines in the Mecca area long before the time of Muhammad. But the Prophet-a citizen of Mecca and a member of a clan from the Quraysh tribe that held the hereditary custodianship of the Kaaba-completely reformed the pagan rites that had been practiced up to his time. He abolished all idolatrous practices and established the orthodox complex of worship that has persisted since his death in A.D. 632. Ten years before his death he had moved his persecuted followers to Yathrib (now Medina, "the city"), eleven days by camel caravan to the north. This exodus of the founding

community of Muslims marks the beginning of the Islamic calendar. Medina is visited every year by thousands of pilgrims eager to pray in the mosque where the Prophet taught and which now shelters his tomb.

The various Islamic sects and theological schools prescribe or recommend slightly different procedures for the pilgrimage, or hajj. But all Muslims adhere strictly to the main rituals of the hajj as we describe them here according to our own separate experiences. A Muslim is obligated to perform the hajj only if he is able to endure the hardship of travel, if the journey does not endanger his life or possessions, and if he can afford the cost of transport and provisions. Yet in their devotion to Allah, and in their quest of his mercy, the poor are legion who make their way to the holy places, bringing along no more than a mat and a

Overleaf: For three days during the annual Muslim pilgrimage, the outskirts of Mina are transformed into a huge tent colony. Those who can afford expensive rates stay at hotels or rent apartments in the town.

The ritual attire of these pilgrims on the Mount of Mercy signifies their submission to the will of Allah. This special garb is worn by rich and poor alike.









At the slaughter area in Mina, pilgrims carve the carcasses of sacrificial animals. After personal and family needs have been met, surplus meat is distributed among the poor.

cooking pot. Although not required to do so, the crippled and the feeble partake in the sacred rites, carried around by their relatives, often in homemade contrivances. So do the very old, many of whom die on the hajj every year—a blessed death some may have sought.

The sacred district of Mecca extends about fifteen miles around the holy city, and the entire area is forbidden to non-Muslims. An extensive catalog of canonic rules defines a pilgrim's conduct during the hajj. On or before reaching designated points along the roads leading to Mecca from the four cardinal directions, a pilgrim must exchange his ordinary clothes for special garb. Before donning this pilgrimage dress, he should bathe or, if that is impossible, perform the ablutions required for every prayer. He then prays to announce to Allah his intent to make the hajj. A man covers his body with two pieces of seamless cloth, usually white, wrapping one piece around his waist and draping the other around his chest, leaving the right shoulder bare. He must leave his head uncovered and wear sandals. A woman, who may make the pilgrimage only if accompanied by her husband or a kinsman other than one whom she could marry, dons an anklelength, long-sleeved dress and hides her hair under a white head cover over which she places a long white kerchief.

This attire expresses a pilgrim's submission to Allah's will-islam means "surrender"-and symbolizes a consecrated status called ihram. From now until the lapidation (symbolic stoning) of the devil on the day after worshiping at Arafat (known as "standing at Arafat"), a pilgrim should frequently repeat the special hajj invocation: "Here I am before Thee, O Allah / Thou hast no equal / Praise and gratitude be to Thee and all grace is Thine alone / Thine is the kingdom / Thou hast no equal." Over and over, pilgrims also call out, alone or in unison with others, "Labbaik, Allahumma, labbaik"-an exclamation that preserves the ancient cry of devotion used by those approaching the Kaaba before Muhammad's time.

While in ihram a pilgrim must be

humble and courteous at all times. Quarreling, gossiping, and any sign of anger or ill temper must be avoided lest the consecrated state be impaired. The following acts are strictly prohibited while in ihram: removing any hair from the body or paring nails, covering the head and wearing garments with seams (for men), using perfumes and adornments, hunting, marrying, and any sexual contact. A violation of the first four taboos can be atoned by either fasting, feeding poor people, or offering an animal in sacrifice. Sexual intercourse invalidates the pilgrimage and requires, moreover, the sacrifice of a camel or a cow as atonement. Sexual contacts such as kissing and touching, although forbidden, do not spoil the hajj, but a goat must be sacrificed if ejaculation occurs.

On "the day of preparation," which can be no later than the eighth day of the pilgrimage month, a pilgrim begins the sacred journey at the mosque in Mecca with the circumambulation of the Kaaba. Built in the center of the mosque's large courtyard, the Kaaba is a cubical edifice measuring about thirty-six feet long, thirty feet wide, and forty-five feet high. A huge black curtain, magnificently embroidered with goldand silver-threaded ornamental inscriptions of Koranic verses, drapes its walls.

According to legend, Adam worshiped at this site, and it was here that, after the Deluge, Abraham, the patriarch of the Arabs, and his son Ishmael built the Kaaba. During the fourteen centuries of Islamic history, the edifice has been rebuilt and remodeled several times. The last restorations were made by the Saudi Arabian government in the late 1950s.

The pilgrims circle the Kaaba seven times counterclockwise, reciting a different series of invocations on each round. They start at the southeastern corner, where a heavy silver frame braces the famous Black Stone. Early Islamic historians report a folk belief that the Black Stone was originally sent to Adam from heaven. After the Deluge, according to legends about the building of the Kaaba, the angel Gabriel unearthed the stone on a hill near Mecca (where the Flood had buried it) and



brought it to Abraham, who then restored it to the sacred place. The pilgrims respond to the mystery of the Black Stone with frenzy. Few Muslims complete their ambulations without trying to kiss or touch its worn concave surface.

But on the eighth day of the pilgrimage month and throughout the night, only the very strong and very patient succeed in their struggle to reach the corner through the whirling crowd. Others must content themselves with pressing their cheeks and hands against the adjoining walls of the Kaaba. They are still fortunate, for most people can do no more than raise their

arms in pious salutation each time they pass the corner on their course. Still farther away, on a slightly raised walkway, hired bearers carry in wooden litters those unable to walk.

Having concluded the required circum-

Having concluded the required circumambulations, a pilgrim may stop for prayer at a small shrine located in front of the Kaaba's gate. In this tiny, glass-walled building, called Abraham's Station, one can see a stone with deep impressions of two human feet. They are believed to have been made by Abraham when he used this slab as a scaffold stand during the building of the Kaaba.

Most pilgrims now go to a nearby subterranean room, where pipes distribute water from the Zamzam, a holy well, to several spouts. Those wishing to avoid the pressing crowd can buy a cup of blessed water from one of the dealers who offer the libation from their vessels. Although to drink water from the Zamzam is an optional rite, every pilgrim is eager to do so and, if possible, to carry some home to share with his family.

The well's legendary origin also dates to the time of Abraham. Once when left alone by Abraham, Hagar, the mother of his son Ishmael, exhausted her supply of water. Fearing the worst for the infant, Hagar laid him down on the ground and went on a desperate search for a well through the arid valleys that converge in the area now occupied by Mecca. Seven times, the legend explains, Hagar ran vainly between the nearby hills of Safa and Marwa. But when she returned to Ishmael, a spring had appeared at the very spot.

To commemorate Hagar's plight, and to glorify Allah for his mercy, every pilgrim

Positions of the Daily Muslim Prayer Ritual

Takbire tahrimah, Beginning of service 2. Qiyam, Recital of the Koran 3. Ruku, Bowing low 4. Sajdah, Prostration









must walk seven times between the two knolls, a distance of a little more than a third of a mile. The pilgrim can perform this rite either at this stage of the hajj or upon returning to Mecca to dissolve his ihram at the end of the pilgrimage. Today the course runs through an arcaded walkway that adjoins the mosque's eastern hall and extends beyond it to the north. On each traverse a pilgrim should recite a different series of special invocations according to his knowledge of the Koran. In addition, a man should imitate Hagar's frightened movements by switching from a walk to a run between certain markers along the course. (Although women are exempted from quickening their pace in this fashion, many do so, possibly to prevent their becoming separated from their male "guardians.") Pilgrims who cannot endure the task may ride in little carriages resembling strollers on the two central lanes reserved for this purpose.

From Mecca the pilgrims proceed to the town of Mina, less than four miles to the east, and from there to Arafat. A pilgrim may stay in Mina to attend the noon, afternoon, sunset, and evening prayers of the eighth day, and the dawn prayer of the ninth; or he may go directly to Arafat.

On the ninth day, the standing at Arafat, Allah and his angels descend to the heaven nearest to earth. Pleased with the sight of the worshiping multitude, Allah extends his mercy to those who ask his forgiveness and protection. To "stand" at Arafat together with uncounted other faithful is an extraordinary experience of Islamic fellowship. Each pilgrim knows that this day is the crucial point of the hajj, and he devotes

his time to prayer and devout reading. The invocation one recites at Arafat is the longest of the hajj litanies. It consists of more than 400 lines that include the following petitions:

O Allah, let not remain
Any of our sins unforgiven
At this sacred place.
And any anxiety unrelieved,
And any loss unreturned,
And any anguish unsoothed,
And any debt unsettled,
And any enemy unchecked,
And any wickedness uncorrected,
And any sick unhealed,
And any void unfilled by Thee,
And any need that meets Thy pleasure
And our welfare unprovided
In the world and the hereafter.

The standing at Arafat ends after sunset. Then the largest traffic jam on earth begins. Throughout the early evening hours the pilgrims leave the camp. Wave upon wave of people move on foot along wide, special roads. Those trapped in their vehicles must endure many hours of waiting and slow progress amidst the cacophonous crowd.

About midway to Mina the pilgrims stop at a place called Muzdalifa, where they perform the sunset and evening prayers in one composite act of worship. Although it is desirable to remain until after the dawn prayer as the Prophet did, one may proceed to Mina after midnight. At Muzdalifa the pilgrims collect the forty-nine pebbles for the lapidation of the devil that will take place in the following days.

In Mina the vast majority of pilgrims

5. Jalsa, How to sit between and after prostrations

6. Right salaam, Preparation for ending prayer

7. Left salaam, Preparation for ending prayer

8. Dua, Finishing salute









stay in tents, which surround the town, for the next three days. The location and furnishings of a pilgrim's tent site depends on his economic circumstances; this service is provided by his *mutawif*, a guide whose business and responsibility it is to take care of foreign pilgrims. The poor pay as little as \$3 for a shelter of torn canvas. A good tent, mattresses and blankets, electric lighting, and meals for the three-day stay in Mina can be had for roughly \$60. Among the wealthy pilgrims who stay in the hotels and other buildings in Mina are some who rent apartments costing as much as \$4,700 for only these three days.

On the morning of the tenth day, the pilgrims form throngs along a wide road in the center of town. There, a few hundred feet apart, stand three stone pillars surrounded by a wall. The pillars represent the devil in his manifestations as the "big," the "medium," and the "small" shaitan. On this day the pilgrims push up to the pillars and stone the big one. Casting seven pebbles with the right hand, a pilgrim exclaims with each throw, "In the name of Allah; Allah is most great! In obedience to the merciful and in defiance of the devil!"

The lapidation commemorates the well-known Islamic story of Ishmael's would-be sacrifice by his father, Abraham, but the legendary accounts differ on whether it was Abraham or Ishmael who, when tempted by the devil to thwart Allah, repelled the Evil One with stones.

Sometime after this rite, but no later than sunset of the twelfth day, a pilgrim offers his sacrifice. It is usually a sheep or a goat that is bought from one of the many dealers and herdsmen who have come to Mina with their flocks. The pilgrim may either cut the animal's throat himself or appoint someone to slaughter it in his behalf. If a pilgrim cannot afford the sacrifice, he may substitute ten days of fasting-three during the pilgrimage month and seven after his return home. The sacrifice secures his hajj in the sense that it redeems any infraction of the canonic rules that he may have committed either wittingly or unwittingly. In the past a pilgrim distributed among the poor all meat that he did not keep for his own and his family's consumption. Today, the large number of slaughtered goats and sheep far exceeds any immediate use, and the government must deploy bulldozers to bury thousands of careasses.

After the sacrifice, women must have a strand of hair cut. The men ideally should shave their heads and faces, but the vain often settle for having their hair trimmed. Numerous barbers line the streets of Mina to provide this service. When he has completed this rite, which he must do before sunset of the twelfth day, a pilgrim may lay aside his ihram attire. This act lifts all hajj prohibitions except the taboo on sexual intercourse, which remains until he has made another seven circumambulations of the Kaaba.

Since the pilgrims must spend the following two nights in Mina, all except those few who return to their own homes in Mecca or in Jidda remain in their tents or rented rooms. On both the eleventh and the twelfth day every pilgrim must stone all three devils, the small, the medium, and the big one, in that order. Unlike the first lapidation of the big shaitan, however, this task can be delegated to another person.

The pilgrims spend their days in Mina resting, cooking, eating, drying meat, and visiting. Since the Koran explicitly allows pilgrims to engage in trade during their hajj, many foreign pilgrims sell goods they have brought from home, competing with local merchants. The wares range from children's toys to Japanese watches to clothes and toiletries. Iranians and Afghans peddle carpets, Turks sell goat-hair blankets, and Africans offer a wide assortment of strangelooking medicines along with aspirin and Band-Aids. Numerous enterprising young men crisscross the camp with Polaroid cameras, as the pilgrims' demand for a photographic record of their hajj is great.

On the thirteenth day of the month, or the twelfth if they cannot delay their departure, the pilgrims may leave Mina. But many remain in Mecca for several more days, thereby prolonging their stay in the sacred area, and no Muslim leaves without a farewell circuit of the Kaaba, "Allah's most ancient house."

An African trader displays his wares on a street in Mina. Trading among Muslims from various countries is customary at this stage of the pilgrimage.











The Enigmatic Eggplant

This purple immigrant has yet to find its American idiom

If you stood at a busy street corner holding an eggplant and asked passersby what way they preferred to eat the lovely violet vegetable (which is, of course, officially a fruit), you would draw a blank eight times out of ten. The ninth person in your hypothetical sampling would scratch his head and mutter something about moussaka, ratatouille, french-fried eggplant slices, or eggplant Parmigiana. The tenth man would turn you in to the police for making obscene approaches with a mysterious and probably lethal object.

The eggplant is not as American as apple pie. It is an altogether late arrival in the Englishspeaking world. Indeed, no European botanist mentions it before the beginning of the seventeenth century, and the first mention in English did not come until 1767, only 208 years ago. Perhaps because this tender, branching, large-leaved plant requires plenty of sun, it has not captured the hearts and minds of the great mass of northern peoples, who until recently have not had it available in great abundance.

But this must be only a partial explanation, for eggplants will grow beautifully in New York. Witness the name of a leading variety: Improved New York Purple. And yet, there is undoubtedly real confusion about Solanum melongena var. esculen-

tum. The name itself is a puzzle. Actually, there are two English names. Eggplant is the original appellation and seems to derive from a white, egg-shaped variety. This "eggy" eggplant is more frequently encountered in Europe, as is the zebrine strain, which has longitudinal purple-and-white stripes.

By 1800, however, the term "aubergine" had crossed the channel to England, where it is now the accepted name for eggplants of all shades. Aubergine is also the standard French name, and that name, too, has mystified men who might have been wiser. The editors of the Oxford English Dictionary etymologized, with evident dubiety, to the effect that aubergine is the diminutive of French auberge. Any traveler knows that in France an auberge is an inn, but we are told in the O.E.D., on the alleged authority of the great French lexicographer, Littré, that in this fruity and enigmatic case, "auberge" is a variant of "alberge," a word for peach. The O.E.D. also cites a Spanish word for apricot. These are, I submit, unsatisfying if vaguely plausible guesses.

Fortunately, the true explanation is there for all to see in Littre's dictionary, where it has been for more than a century. He states that "aubergine" derives, via Spain, from the Arabic word for eggplant, al-badhinjan. This makes historical sense, and the Arabic term leads, by evident phonological processes, first to al-berenjena (the modern Spanish word for eggplant is the same

minus the Arabic definite article, al: berenjena), and then to aubergine

Various other kinds of documentary evidence collected by Alphonse De Candolle in his Origin of Cultivated Plants build a good case for believing that the eggplant itself was brought to Europe by Muslims who themselves had met with the plant in Africa no later than the dawn of the Middle Ages. Muslim invaders then carried it across the Strait of Gibraltar. But they were only a link in a chain of transmission that had begun in India centuries before. We can be sure that the eggplant was known in the subcontinent in earliest historical times because the Sanskrit word for eggplant, vartta, has survived in the modern Hindi term, bharta.

We may calculate, then, that all cultures between Delhi and North Africa (including those Levantine and Balkan societies that came under Muslim influence) have known and used the eggplant for hundreds of years longer than the peoples of northern Europe and America. And it is, therefore, no wonder that precisely those areas old in familiarity with the plant have developed their own typical recipes, whereas we have barely one. The eggplant cultures also had the paradoxical benefit of learning to like this member of the Solanaceae before they learned systematic botany. The sophisticated perception that eggplant was taxonomically related to the deadly nightshade was the reason our own ancestors avoided it, along with its cousins the tomato and the potato.

It may be for this reason that cookbook writers almost universally still advise us to salt eggplant and let its bitter (that is, poisonous) juice drain away through a colander for 30 minutes before cooking the purified pulp. James Beard has recently dismissed this process as the result of old wives' tales. This squares with my own experience. On the other hand, I have tasted bitter eggplant, but I suspect that the bitterness came from bruising or overripeness.

Picking a good eggplant is easy. Look for a perfect, bright skin without blemishes or dark spots. Cook eggplants as soon as you can. After a couple of days in the refrigerator, they begin to develop soft spots. These can be cut away, but it is much easier and less wasteful not to wait so long that surgery becomes necessary. You will also benefit if you buy small eggplants. Jumbos don't taste as good, and there is a false economy in paying for a giant vegetable filled with seeds. Markets catering to Mediterranean and other eggplant cultures often sell dwarf eggplants, which are the best of all, firm and tasty.

Should you decide to grow your own-and eggplants are an ideal crop for the home gardencalculate that a dozen plants will suffice for most families. Each plant yields two to six fruits, which are edible almost from their first appearance. In New York and similar climates, it is best to start seeds no earlier than March 1, in a greenhouse or other forcing area. Transplant seedlings to flats so that all plants are two inches from each other. Transplant again to four-inch pots. Finally, when the ground is warm and you are sure of good weather, cultivate a sunny plot (lightly, because eggplants are surface rooting) and space the plants four feet apart. Dust lightly with 10-5-10 fertilizer.

Home-grown or bought, eggplants can be cooked in an amazing number of ways. In fact, the only thing you can't do with eggplants is eat them raw. I tried this recently at a "healthy" student restaurant and found it almost impossible to ingurgitate the uncooked peel. Otherwise, the possible array of eggplant dishes spans the entire spectrum of kitchen technology and of national tastes.

Basically, as with most vegetables, eggplant cookery comes down to finding a convenient way to soften the flesh. The first step is to get rid of the peel. A knife will do the trick, of course, but cooks from India to Rabat have simply put the whole, unpeeled eggplant over a flame and roasted it for roughly 30 minutes, until the outside is completely charred and the inside is soft all the way through. Do this on a charcoal grill or by turning the eggplant over a gas burner or under a broiler flame. Afterward, wrap it in a damp towel for 5 minutes; then strip away the skin and mash in a bowl. If the purée is mixed with sesame paste, oil and garlic, you will have Middle



The white variety of eggplant is a common sight in Indonesian markets

Eastern baba g'hanouj, a seductive appetizer to serve with Syrian bread. Eggplant purée mixed with green pepper and tomato is kiopoolu, a Bulgarian spread. Without tomato, you have a Serbian appetizer, ajvar. On Rhodes, they use tomato and puréed raw onion. In India, where these spreads may have originated, people "butter" their bread with bharta-eggplant purée mixed with cooked, chopped tomato and typical Indian spices. Or they may mix it with yogurt, mint, and onion.

It would take a book to set out a complete collection of the world's eggplant recipes. There would have to be an entire chapter for just one kind of baked eggplant, made by first slicing the eggplant in half and then scooping out the raw pulp, which is chopped, sautéed, mixed with other foods (for instance, anchovies or chopped meat or mushrooms) and stuffed back into the shells to be braised in stock or water. Moroccan Jews raise this method to its highest level. They first sauté the emptied eggplant halves, then stuff them with a puréed mixture of sautéed cubed eggplant pulp, tomato, and cubed, blanched brains. Beaten eggs are poured over all and the dish is baked. Inverted on a serving platter, it is served in long slices.

In the Dutch Antilles, where the Indonesian influence is strong, eggplant slices are baked in coconut cream. In Iran, sautéed cubes of eggplant go into an egg pancake. In Hungary they enliven scrambled eggs. In Italy the same cubes are the basis for that cold hors d'oeuvre of a hundred variations, caponata. In France, Simone Beck uses them to fill a quiche.

Or eggplant can be boiled and mixed with lentils, as in India. Or stir-fried with shrimp, as in China. Or deep-fried in batter, as everywhere.

Perhaps the world center for eggplant cookery is now Jerusalem, where for better or worse, most of the diverse cultural strands that connect with the eggplant have come together in a complicated knot. There, according to The Flavor of Jerusalem, a new book by Joan Nathan and Judy Stacey Goldman (Little, Brown, \$8.95), cooks have created baked eggplant à la Golda (slices sautéed in egg and cheese and then baked with a tomato sauce), as well as an eggplant kugel, in which an East European potato dish is transformed into a Middle Eastern baked casserole. Perhaps eggplant can also supply the linkage that Henry Kissinger needs

2 medium eggplants

to cement peace in the Middle East. Eggplant Imam Bayildi has already proved to be a weapon against Muslim strength. This most famous of all eggplant dishes was supposedly first served to a Muslim priest who fainted from joy at its taste. Whence the name: "the Imam was overcome with pleasure." (The recipe below is an adaptation of a version by Elizabeth David.)

Raymond Sokolov is a free-lance writer and food columnist.

Eggplant Imam Bayildi

Oil (preferably olive oil)

I medium onion, peeled and finely chopped

I medium tomato, chopped

Salt

Pepper

4 teaspoon allspice

2 teaspoon chopped parsley

I tablespoon currants, soaked in cold water for 30 minutes

I clove garlic

I bay leaf

- Cut the stems off the eggplants but do not peel. Cut several lengthwise slits in the eggplants but do not slice through.
- Heat 2 tablespoons of olive oil in a small skillet and sauté the onion until it browns lightly.
 Then add tomato, salt, pepper, allspice, and parsley.
 Cook over medium low heat until the mixture breaks down almost into a purée.
- Drain currants, add them to the tomato-onion mixture, and cook for 10 more minutes. Let cool.
- 4. Stuff the cooked mixture in the slits in the eggplants with your fingers or a knife.
- 5. Set the eggplants in a flameproof dish that will just hold them. Pour oil over the eggplants until the oil level is about halfway up them. Add garlic and bay leaf to the oil.
- 6. Cover the dish and cook over very low heat for an hour or until the eggplants are very soft. Turn them every 15 minutes. When done, pour off excess oil and strain and store for reuse. Cool and refrigerate eggplants overnight. Serve cold in thin slices.

Yield: Six servings, as an appetizer or side dish.

Celestial Events

by Thomas D. Nicholson

Sun and Moon On May 14, the sun moves into Taurus, where it remains through mid-June, moving steadily north as its easterly motion along the ecliptic takes it toward the summer solstice. Daylight continues to lengthen, but at a slower pace; the earliest sunrise of the year occurs about June 13, but sunsets occur later until late June.

The moon reaches first-quarter phase on the 18th; full on the 25th, Waning thereafter and rising after sundown, it becomes last-quarter on June 1 and new moon on June 16. There will be a total lunar eclipse, partly visible in the Americas, with the full moon of May 25.

Stars and Planets Three planets may be seen after sundown: two of them, Venus and Saturn, appear close together on our map. Venus is very bright in the west for several hours after sunset, with Saturn to its left and higher until late May, thereafter to its right and lower. And Mercury is in good position as an evening star from mid-May to month's end. Look for it below and to the right of Venus before twilight ends. Mars and Jupiter are morning stars, visible in the early dawn in the southeast, with no bright stars in the area to compete. Jupiter is the lower and brighter of the two.

May 14: The early crescent moon, Venus, and Saturn make an interesting trio in the western sky this evening. Venus is the brighter planet. Mercury, below Venus and to the right is about as bright as Saturn.

May 16: Mercury is at its greatest distance to the left of the sun in the evening sky (greatest easterly elongation).

May 20: The moon is at perigee, nearest earth.

May 23: Venus and Saturn are in conjunction. In the evening sky, Venus has been to the west (right) of Saturn; moving to the east (left), it is now higher than Saturn.

May 24–25: Tonight's total lunar eclipse begins at 11:00 P.M., and ends at 2:36 A.M., EST. Total eclipse, when the moon is completely within earth's shadow, lasts from 12:03 A.M. to 1:33 A.M., EST. Adjust for the effect of daylight time by adding one hour; subtract one hour for each time zone to the west of the eastern zone.

May 29: Mercury begins its westward (retrograde) motion.

May 30: The two bright stars near Venus tonight are Pollux and Castor, the Twins, in Gemini.

June 1: The moon is at apogee, farthest from earth.

June 4: The bright object below the moon this morning is Mars; Jupiter is lower and to the left.

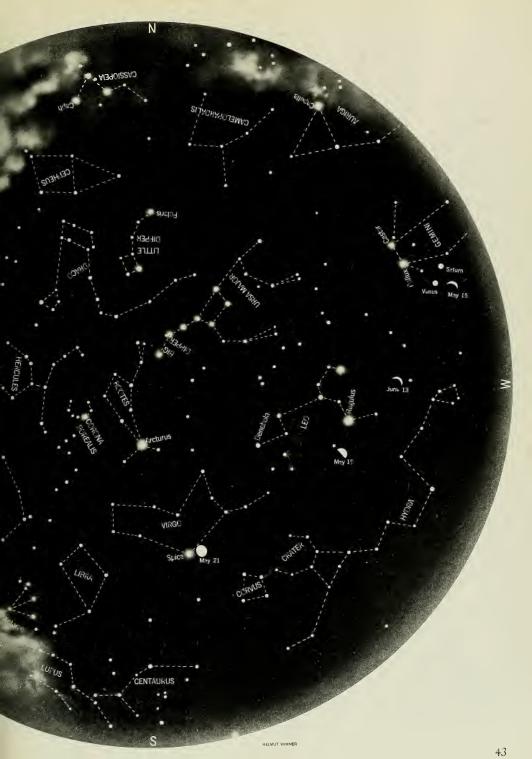
June 10: Mercury passes between earth and sun (inferior conjunction) and enters the morning sky. Saturn, very low in the west this evening, is near the crescent moon.

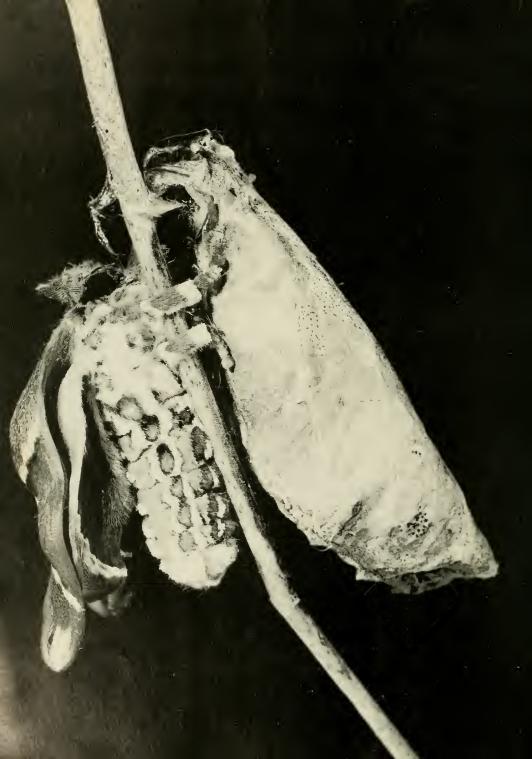
June 12-13: The moon passes from right to left below Venus. It is near the bright planet on both evenings.

June 14: The moon is at perigee, nearest earth.

*Hold the star map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:25 P.M. on May 15; 9:25 P.M. on May 31; and 8:25 P.M. on June 15; but it can also be used for about an hour before and after these times.







Silk Moth of the Railroad Yards

Confined to the sterile backyards of eastern United States cities, this lovely insect is thriving while other members of its family are dwindling

There is nothing readily apparent about the cynthia moth that should single it out for ecological favors. Yet this lovely insect, one of the giant silk moths, may be the only member of the family Saturniidae to survive this century in much of the eastern United States. Among the sixty members of the family that inhabit North America, Samia cynthia is the only one that is not indigenous. Of the native species, many are endemic to the eastern hardwood belt, while others inhabit narrow west coast ranges. The family has a worldwide distribution-an Asian representative (Attacus atlas) is the largest moth or butterfly in the world. with a wingspan of almost a foot.

For the last ten years, entomologists and conservationists have been concerned about the vast general decline in numbers of giant silk moths. Formerly abundant species such as luna, cecropia, promethea, and polyphemus moths are now scarce. The demise of this moth family is not unique; many populations of Lepidoptera (butterflies and moths) have diminished in the last few decades, and an entire latter-day offshoot of the wildlife conservation movement has focused around these insects.

But the plight of the giant silk moths, with the exception of the cynthia moth, seems to be more severe and more pervasive than that of most other moths and butterflies.

In the past, researchers have put forward several theories to account for the severe diminution of saturniid moths. Some blame habitat destruction, by far the biggest culprit in most cases of insect decline; but silk moth populations are low even where the land remains undisturbed. Others suggest that pesticides are the principal cause of devastation; yet while local extermination occurs in areas of heavy spraying, the general levels of chemicals in the environment have not been positively correlated with silk moth disappearance. Besides, many other moths and butterflies have maintained fairly high populations in districts now devoid of saturniids. The ornithologist Roger Tory Peterson suggests that smog might affect the reproductive ability of the moths by masking the sex pheromones by which they locate mates. The success of captive cynthia females in attracting males even in New York City, however, contradicts this idea.

Most lepidopterists now subscribe to an altogether different theory, advanced by Douglas Ferguson, which blames the wide use of mercury vapor streetlights. The large moths, powerfully dazzled by the ultraviolet emitted by these lamps, may be killed by predators or by cars traveling under the lights. But more likely, the moths are drawn by the lights far from their usual habitat and are unable to find larval food in an unknown area. Finally, since males seem to be more strongly attracted to the lights than are females, the normal courtship behavior may be interrupted, resulting in nonfertilization of eggs.

Whatever the actual cause of

silk moth disappearance may be, the cynthia moth does not seem to be seriously affected. The moth flies on broad vanes of warm olive tan blending into buckskin margins. Each of the four long wings bears a creamy central lunule edged with golden scales. The points of these crescents just reach the pale mauve band that traverses the wings. One of the most subtly pleasing features of the moth's beauty is the wrinkled lilac patch, punctuated by a blue eyespot, in the apex of each forewing. These hues and patterns, made up of thousands of tiny scales, color a set of wings that may spread six inches on a large female.

The cynthia moth was introduced to France from China and India in the last century, and from there to Philadelphia in 1861. Numerous other introductions were made in eastern seaboard cities, the motive being to boost the failing American silk industry. For a number of years the industry in this country had been based on the cocoons of Bombyx mori, the silk moth traditionally used for silk manufacture. The particular mulberry trees upon which B. mori fed, which had been introduced with the moth, however, could not withstand the repeatedly harsh New England winters. The silk industry in America seemed doomed until the cynthia moth arrived, along with its principal food source, now variously known as tree of heaven, paradise tree, and stinkweed (Ailanthus altissima). The big new moths were easily raised and made large cocoons. Their food plant proliferated.

As much silk as the cynthia moth cocoons contained, however, it could not be successfully harvested. The silk of the *B. mori* cocoon can be easily unwound into several miles of unbroken thread, but the fiber of the cynthia moth's cocoon is thinner, weaker, and ce-

After emerging from its cocoon, a cynthia's wings must dry before it can fly. Egg-laden females release pheromones that attract males up to ten miles away.

mented together at many points. The glue can be dissolved, but not without a strong probability of breakage. The complex machinery invented in Europe to circumvent this difficulty proved uneconomical, and the whole venture was dropped before 1900.

The collapse of their commercial usefulness did not mean the end of the cynthia moth and the ailanthus tree in the New World. They both adapted readily to the northeast and extended their ranges. They now occur abundantly in cities from Boston to Washington, D.C., and as far west as Chicago. Further range expansions will depend on the ability of both the moth and the stinkweed to disperse to large cities.

These trees are the exclusive host of the cynthia moth in North America. When the insect first came to this country, observers thought it would exploit many other kinds of broad-leaved trees and shrubs. An entomologist reported in 1881 that cynthia larvae were feeding on nearly all the trees and shrubs in New York's Central Park. But the lack of discrimination by egg-laying females proved deleterious, the moth apparently having a physiological requirement that only the ailanthus tree will satisfy. The same entomologist found that the diverse diet in Central Park caused unusually small caterpillars, most of which died before pupating.

When not thus aborted, the life history of the cynthia moth constitutes a remarkable sequence. In July the female oviposits small rows of oval eggs usually on the undersides of leaflets. Upon hatching, two to three weeks later, the 1/4-inch-long yellow larvae cluster by the dozen or more as they grow and molt, turning green and developing blue tubercles and yellow tips. Highly conspicuous in such form and numbers, they are at this time especially liable to predation. Upon discovering a caterpillar colony, birds may feed upon the larvae until the entire colony is gone. But if they are not detected and survive to the sixth and final molt, a month or so after hatching from the eggs, the four-inch caterpillars resemble miniature distended turquoise serpents. They are blue-jeweled, yellow-pawed lions, rampant as they rear up toward a virgin leaf—and they are eating machines supreme.

Toward the end of summer this efficient foraging terminates. The bloated caterpillar pupates, usually by spinning a cocoon around a leaflet of the ailanthus. Before doing this, however, it performs a remarkable feat by actually lashing the chosen leaflet to the tree. As the ailanthus tree bears compound leaves, anchoring the leaflet is not enough, since the entire leaf, and thus the cocoon, will fall to the ground in the autumn. The larva therefore spins a silken cord from the leaflet along the leaf's long petiole to the place where it joins the branch. Here, the larva anchors the cord, which may be as long as eighteen inches.

When the leaf falls in the autumn, it, together with the cocoon, will dangle in the air. As Long Island lepidopterist John Cryan has found, the long lash serves a protective purpose beyond mere attachment. When struck—by a bird's beak, for example—the cocoon swings like a pendulum, absorbing the blow.

In its final hours as a caterpillar, the moth wraps itself inside a leaflet and spins a double-walled cocoon. Thousands of yards of silk go into the powerful mesh construction, which forms first an outer, looser sack and then an encasement within, like hard-pressed cardboard. The final molt takes place within this two-inch, blimplike chamber. Out of the shriveled and split larval skin wriggles a stout, brown pupa with the suggestions of the moth's form-wings, antennae, body segmentssculpted in its shiny surface. No idle sarcophagous, this thin case encloses one of the most incredible transformations in nature.

Through autumn, winter, and spring, the creature dangles quietly, its unexpected splendor hidden by a grim shroud. Then on a summer evening, the finished moth secretes a clear drop of solvent from its head to clear an exit from one end of the cocoon. With

Before mating, the male cynthia moth and the slightly larger female go through an elaborate courtship dance, which may last from early evening until dawn.

damp, folded, and compressed wings, the adult crawls into the air.

After hanging from a leaf or twig to spread and dry their massive wings, female moths release pheromones. Males, sensing these perfumes with their large, feathery antennae, may be drawn from five or ten miles away to mate with the females. Courtship and pairing often go on until dawn.

Like all saturniid moths, cynthias have no functional mouthparts. All adult activity must be sustained on energy stored by the caterpillar, so the life of the moth is short—perhaps only a few days. But sometime during those days new chalky eggs will have been fertilized and laid.

This cyclic miracle takes place only where ailanthus trees grow, but only if they are in the neglected and denigrated corners of eastern cities. In spite of one of its common names, tree of heaven, the ailanthus prospers in the least heavenly niche of all. It competes poorly with native trees and shrubs in woodlands and has limited use as an ornamental in gardens and parks. But wherever the growing is tough, this adaptable plant spreads its roots, capable of vegetative reproduction, to find bits of soil to exploit. And where the tree of heaven strikes a claim among concrete and broken bricks, the cynthia moth follows.

An abundance of evidence corroborates the moth's unwholesome preferences. Sandy and Paul Russell, amateur saturniid researchers in Brooklyn, find the largest numbers of cocoons between the bases of the Manhattan and Brooklyn Bridges, among garbage dumps, abandoned factories, and warehouses. Lepidopterist Cryan seeks the species in old air bases and shipyards and in alleyways. My own experience suggests that railroad yards are especially suitable







havens for the insect, an impression reiterated by many students of cynthia distribution. This seems not to be a new association. New York naturalist Bernard Sherak earned spending money during the Depression by providing quantities of cynthia pupae, gleaned from Brooklyn railroad yards, to biological supply houses. But while Sherak knew enough to leave pockets of cocoons unexploited for repropagation, the cynthia moth's habit of clustering makes it easy prey for unscrupulous collectors. A selfish market collector recently removed every cocoon, about 500, from a dismal New Haven, Connecticut, railroad yard.

Some sites are favored over others. In an effort to further characterize the features of cynthia's habitat, I compared two stretches of ailanthus-lined railroad track in New Haven. The first section I ex-

A female cynthia lays 300 to 400 eggs, usually on the underside of a leaf. These hatch in two or three weeks. A month after hatching, the caterpillar is four inches long. Its tubercles probably serve to scare off predators.

amined is an old spur line, which while littered, makes a rather pleasant green strip through the city. The flora along the tracks, which run along an abandoned canal bed, grew densely and variously. Where maples were backed up against the bank, shards of broken glass were hidden by a carpet of yellow leaves. Locust and catalpa trees lined other sections, while mullein spread its furry rosettes among the rock ballast, and





Dependent on ailanthus trees, which grow in isolated urban niches, a cynthia population may be easily exterminated by cocoon collectors.

milkweed broadcast silky seeds into the autumn wind.

These trees, shrubs, and herbs created a great deal of cover, which was exploited by a surprising amount of wildlife. Mourning doves crowded on overhead wires. Blue jays, never out of earshot and seldom out of sight, lurked among the scrub. English and white-throated sparrows hopped ahead of me in foraging flocks. A crow lumbered overhead, while a gray squirrel ran along a rail and a rat slunk up the side of an embankment. Starlings were my constant companions.

Trees of heaven grew all along the spur, having sprung from rock and brick and concrete. Their leaves fell away with the wind. But the loss of foliage revealed not a single cynthia moth cocoon along this stretch of the

road.

I next visited the New Haven railroad yards, where city senescence meets railway decay in a very bleak setting. Here were all those aspects of the city that make urban existence so difficult for the naturalist. Stark parallel patterns of tracks, wires, roads, and pipes blocked the view, while traffic dinned and fumes filled the air. A sterile scene, yet the cynthia was there in abundance.

Scores of sleeping moths were suspended in a skeleton of stinkweeds along a soiled wall. Compositions in silk and soot, the new cocoons looked fresh and pink next to the previous year's discarded gray ones. But the scenario hardly sparkled with life. Fingerlike ailanthus grew prolifically, but practically the only other growth was a stand of reeds, which partially concealed the snout of a steaming locomotive. I began to understand the moths' remarkable adaptive strategies. To live in this habitat at all is an achievement;

but the moth did more than that—it lived well.

Swaying from nearly every limb, woven into one another in the absence of a better substrate, even set into the diamonds of a chain link fence, the cocoons offered a rich and vulnerable food resource for would-be predators. Even with their tough shells and swinging suspension, some of them would certainly fall victim to birds or mammals that happened upon them.

And yet here, I suspect, lies the secret of the cynthia moth's success in the inner cities: there are virtually no predators here. For, unlike the well-vegetated spur line, this railroad yard evidenced no vertebrate life. Even the wasp and fly parasites that attack many Lepidoptera larvae were not observed in a sample of cocoons from the site. Parasitism of the cynthia seems to be infrequent in many other populations as well.

The low incidence of predation in certain habitats emerges as a theory for the prolific existence of cynthia moths. While few populations are actually controlled by predators, the survival of these saturniid moths appears to get a significant boost from lack of enemies. This could be especially important in the hostile environment of the inner city, where pressures such as the removal of ailanthus trees, vehicle-caused mortality, and occasional overcollecting by humans act against the moths.

Assuming, however, that a few predators stalk the urban wasteland, the cynthia moth may already be evolving into an even better urban strategist. Nineteenth-century entomologists noted that the species was genetically very plastic, capable of rapid evolutionary change. American cynthia moths were reputed to be noticeably different from the French and Chinese stock after being here only a few years. Now, subjected to twentieth-century pollution, the moth appears to be evolving a degree of melanism.

Charles Remington, a Yale University biologist specializing in insect evolution, has watched New Haven and other urban cynthia

moth populations for more than twenty years. Certain color mutations are quite evident, one of them producing a striking black insect. In New York City, the Russells have discerned a strongly gray-flecked form, which predominates among the moths they rear for experiments. Of all the mutations that could arise, melanism would be one of the most advantageous in the sooty environment of the railroad yard if there were just enough predators to select for it.

One big question remains to be answered in this portrait of a moth and its curious distribution. If mercury vapor lights are indeed the principal factor in the depletion of saturniid moth faunas, why does the cynthia remain abundant in places where mercury vapor lights glow intensely? Elaborate experiments might give the answer; in the meantime, lepidopterists can only speculate. My own speculation is that lights, ordinarily situated close to the cynthia's habitat, might serve to concentrate the moth in places with a high probability of ailanthus occurring-the cities. Since the drawing power of female pheromones is almost certainly more far-reaching than that of the streetlights, mercury vapor lights are not likely to remove male moths from the vicinity of females. The immunity of city cynthias to modern lighting seems to be rooted in the very nature of the moths' urban habitat. Once again, the cynthia moth demonstrates its elegant adaptation to urban exis-

While many forms of wildlife perish before expanding human populations, other animals and plants have adapted well to the marginal habitats spurned by people. Foxes breed commonly in London, raccoons populate New York City parks, and beavers are at home in Seattle waterways. The cynthia moth appears to be another creature adroitly adapted to the rigorous urban environment. Whatever the cynthia is doing, it is doing it right. For while giant silk moths of other species disappear, the cynthia thrives in the cities. And the cities are richer for it.

Vintage Pompeii

by Wilhelmina F. Jashemski

Buried in the ash of this ancient city is a story of flourishing vineyards, busy wine shops, and taverns where thirsty crowds gathered

Bacchus, god of the vine, was an enormously popular deity in ancient Pompeii, where wine was one of the staples of life. It is not surprising, therefore, to find that the ancient Pompeian frequently decorated the walls of his home with paintings of grapes and grapevines, and likewise used the motif in his garden sculpture and to decorate pots and pans.

With reason could the poet Martial claim that Vesuvius was the fa-

vorite haunt of Bacchus:

This is Vesuvius, green yesterday with the shade of vines; here the noble grape loaded the dripping vats; these ridges Bacchus loved!

Wine production in the fertile area surrounding Vesuvius was an important activity. Pliny the Elder, who perished during the eruption of Vesuvius in A.D. 79, devotes the fourteenth book of his Natural History to the grape-its cultivation, varieties, and uses. Among the varieties mentioned are several from the Pompeii area. Today's famous Lacrima Christi is made from grapes grown on the slopes of Vesuvius. Of the villas that have been excavated thus far, the majority have had facilities for making wine, much of which must have been sold at Pompeii.

Even the most casual visitor to Pompeii is aware of the provisions ancient Pompeians made for buying food and drink in their city. Scarcely a block is without its tavern or "quick lunch" counter. Two paintings found on the walls of a tavern near the Forum show how wine was brought in from the country in a large animal skin carried on a wagon. The neck of the animal skin was tied and one of the legs used as a spigot. If the order was large, the delivery boys unharnessed the horses while they filled the large terra-cotta amphorae. Specialty and imported wines were probably delivered directly in amphorae.

The many amphorae found at Pompeii vary greatly in size and shape. Some are inscribed with such information as the name of the producer, the contents and weight of the amphora, the name of the estate or villa on which the contents were produced, and the name of the person to whom the amphora was being sent. Inscriptions tell us that the Pompeians enjoyed wines imported from Crete, Sicily, Spain, Cnidus and Cos. There is evidence, too, that the Pompeians exported wine.

The many gardens at Pompeii indicate that it was not at all unusual for the ancient Pompeian to produce at least some of his own table grapes or wine. He might have had many vines or, as was frequently the case, only those that formed the arbor, or pergola, shading his garden eating area. Judging from the many masonry triclinia-used for reclining at meals-found in the gardens of homes, inns, and restaurants, eating outdoors was extremely popular. Ancient Romans preferred to recline while eating, although slaves and the poor probably sat on stools at a table. Martial speaks disparagingly of "eating places with stools" and taunts the boor who does not recline to eat. Wall paintings found at Pompeii show the triclinia made comfortable with mattresses and pillows. Vinecovered pergolas graced the gardens of both the wealthy and the humble, and in a modest orchard that we excavated on the Via Nuceria, we found the cavities, still reinforced with stone, that held the posts of the pergola, as well as the cavities of the vines that shaded the triclinium.

Most surprising, however, was our discovery of a large, scientifically planted vineyard within the city walls. For more than 200 years the large city block to the north of the amphitheater had been known as the cattle market. This valuable property, located at the eastern edge of the city, faces the largest thoroughfare in the city, the Via dell'Abbondonza. There have been sporadic excavations in this city block, or insula, throughout the years. The first were in 1755, at which time the site was identified as a cattle market. When the south wall of the insula was uncovered in 1814, excavators found an entrance in the wall directly across from the amphitheater and, just inside the entrance, a masonry dining triclinium. Some scholars believed it to be the place where gladiators killed in the amphitheater were buried, perhaps because this discovery followed that of another triclinium, just outside the city wall, built as a tomb monument. Others believed that the cages of the animals used in the amphitheater were kept in this insula, for the amphitheater is the oldest known and, unlike later ones, had no underground provisions for animals.

There were no further excavations until the 1950s, when much of the insula was uncovered. Although two rooms excavated in the northwest part were equipped for making wine, thus suggesting that the insula might have been planted in grapevines, the belief persisted that this area was the cattle market.

Only subsoil excavation could determine if this important prop-

erty had been planted. If the modern overgrowth has not been too destructive, it is possible to find evidence of the roots of trees and plants that were growing at the time Vesuvius erupted, for the lapilli (volcanic debris), which covered the city, slowly filled the cavities left by the decayed roots. Fortunately, this area had less destructive vegetation than most, so I was hopeful that we could determine whether it had been planted. I began this study in 1966. Our first trench, dug along the east wall where there was a substantial covering of original volcanic debris, almost immediately yielded encouraging results. Removing four feet of lapilli, we came to the ground level of A.D. 79 and found a cavity filled with lapilli. After the lapilli had been removed we found that the cavity was a perfect mold of an ancient tree root, nearly a foot in diameter at ground level.

As we continued our trench, however, we discovered that the excavators in 1953 had removed the volcanic debris down to the original level and later covered the area with backfill. Days of hard work yielded only a few scattered root cavities 1½ to 3½ inches in diameter. Eventually our luck changed, and we began to find evenly spaced root cavities, then row after row of cavities. It began to look as if there had been much planting in the cattle market.

We carefully emptied, measured, and filled the cavities with cement. After three days we pulled the soil away from the casts, revealing the shape of the roots that had been growing at the time of the eruption. By the end of the summer we had found five large tree root cavities and more than 200 vine root cavities. There was, as well, a second cavity at most locations; if these were also roots and not stakes, then we found nearly twice that number of vine

roots. This important area was obviously a vineyard and not the cattle market, as had been believed for so many years.

During the summer of 1968, much of the insula was further excavated. In parts, particularly the western half, where the original surface had been badly damaged by the passage of trucks, the work was extremely tedious and difficult. But by the end of the summer we had found more than 1,200 vine root cavities (still counting only one vine root to a location), making a total of 1,423.

The vines in this vineyard were planted with remarkable precision, almost exactly four Roman feat apart (1 Roman foot = 11.66 inches), which would indicate that they were cultivated by hand. Columella, the author of an ancient Roman manual on agriculture, wrote that rows should be at least seven feet apart if cultivated by oxen and plow. Pliny the Elder may well have been reporting the practice in this area when he said that in rich soils vines should be planted four feet apart.

There were three or four depressions around the root cavities, which our local workmen immediately recognized as similar to those they put around their own vines to hold water.

We resumed our work during the summer of 1970. Through the assistance of Prof. Alfonso de Franciscis and the Ministry at Rome, a portion of the hill of original volcanic debris and accumulated soil (about eighteen feet in height) had been removed down to three feet of lapilli. This made it possible to begin excavating an area that had not been damaged by earlier excavators. Because the cavities previously excavated had been badly disturbed, we could not be certain that there were originally two cavities in each location, nor could we determine if the second cavity was that of a stake or another root. Local growers, who were much interested in the discovery of an ancient vineyard, unanimously insisted that the vines had been staked in antiquity, just as they are today. But fruit experts at the University of Naples believed that the second cavity was that of another root, and that the vines had been pruned low and left unstaked.

With great excitement we began to empty the cavities, which were perfectly preserved. Again making cement molds of the cavities, we found that one was almost always that of a vine root, easily identified by its shape and small lateral roots. And the second was that of a stake. We had now found a total of more than 2.000 vine roots.

Columella recommends that vineyards be divided by footpaths for the use of the proprietor and the laborers in carrying fruit, stakes, or repairs for frames. He also advises that vineyards be divided into areas of 0.5 juger (less than half an acre), which is approximately the size of each quarter of this vineyard. In 1966 we had discovered a north-south path leading from the entrance of the vineyard. In 1968 an east-west path was uncovered, located a little off center, giving access to an outdoor masonry triclinium just outside the door to the rooms where the wine was made.

The perfectly preserved cavities on each side of the paths could be easily identified. The large ones that outlined the path were those of posts; the smaller cavities to the side of the posts were those of vine roots. The posts, which formed the supports for an arbored passageway, were probably made of chestnut. recommended by Pliny for its "obstinate durability." The ancient agricultural writers also recommended growing poplars and willows to furnish ties for the vines, a

practice that is also still followed.

We found a total of fifty-eight tree root cavities, the diameter at ground level ranging in size from 1.4 inches to 15.7 inches. Trees were usually planted at the edges of the vineyard between the second and third rows from the walls, with a few trees placed randomly throughout the vineyard. At first the small cavities baffled us, but we soon realized they were volunteer seedlings such as we saw growing in modern vineyards. In the area today, farmers still plant fruit and nut trees in vineyards, as was the ancient practice.

Near one tree root cavity we discovered two carbonized olives. Part of the flesh of the fruit was still visible on the seed, the striations quite marked, and the characteristic stem and collar still on the fruit. This was an exciting find, for previous excavators had found carbonized fruit and nuts in shops and cupboards, but this was the first time such a find had been made in a garden, showing the actual conditions of culture.

The excavation of this vineyard enables us to visualize the entire process involved in the wine industry, beginning with the planting of the vines and the culture of the grapes, through the making of the wine, and the sale of the final product. The small building used to make the wine consists of a rustic room with fittings for a wine press. After the juice was extracted, it was stored for fermentation in very large earthenware jars (dolia) embedded in the dirt floor of the open shed near the press.

We can be sure that our winegrower did a thriving business serving customers at his two triclinia: one located, as described earlier, just inside the entrance to his vineyard across from the amphitheater; the other, just outside the wine shed where the juice was fermented. We know that spectators thronged to Pompeii during the games and would patronize nearby eating places to supplement the food and drink they brought with them.

Wine from this vineyard was probably also sold in a shop that belonged to the owner and fronted on the busy Via dell'Abbondonza. We excavated this shop and found that it had a single masonry counter with three step-shelves for glasses and cups. Four columns originally stood at the edge of the walk in front of the shop, undoubtedly supporting a roof to protect passersby who stopped to buy wine.

During the course of our excavation of this vineyard, we found numerous bones. Some of them were marked with tools or had been split to obtain marrow, suggesting that they were the remains of meals served in the vineyard. The discovery of bones and their identification as debris from meals (although some perhaps were the bones of animals that had fled into the vineyard during the eruption) finally explains why this insula was mistaken by the first excavators for a cattle market.

We found seventeen coins in the vineyard, all coined between A.D. 22 and 74 and in circulation during the last days of the city. How much buying power did these coins represent? Although various graffiti listing the prices of commonly bought products have been found at Pompeii, quantities are not given. Perhaps a good index is the price of a serving of wine. The prices charged by the barmaid Hedone, who promises customers a drink for one as, a better drink for two. and the famous Falerian wine for four, probably reflect prices throughout the city. The drink sold for one as would be the local wine, such as was produced and sold in this vineyard.

This vineyard was not the only one in Pompeii, although it was the largest and the first discovered. Its particular significance lies in its confirmation of practices recommended by the Roman agricultural manuals. In the smaller vinevard located near the Nucerian Gate, the distances between the vines were less precise. But this property is of special interest because it provides us with a picture of another method of wine production in the city. Ripened grapes were brought to a small one-room building in the northeast corner of the property and there trodden by foot. The ancients considered wine made from juice obtained in this way much better than that extracted with a press, which bruised the seeds. But in antiquity, as today, the trodden grape skins were sometimes put in a press for one or two pressings.

Although the Romans consumed some of the freshly pressed juice (known as must) before it was fermented, and even knew how to preserve it, most of the juice was stored for fermentation. Stairs near the east wall of the vineyard lead to a large underground wine cellar in a corner of the garden. A large vat in which the must was allowed to stand and ferment occupies the south end of the cellar. The must was poured directly into this vat through an opening at ground level in the roof of the wine cellar. A bottomless dolium, set at ground level over the center of the room, and a door at the end of the room probably supplied the necessary aeration. If such precautions are not taken, fermentation produces deadly amounts of carbon dioxide.

Elaborate preparations, for which Columella gives detailed instructions in his manual, preceded the making of new wine each autumn. Baskets were woven for picking the grapes, and small hooks and sickles were procured

An extremely popular deity in ancient Pompeii, Bacchus, god of the vine, figures in numerous art works. Like many paintings found on household shrines, this one from the House of the Centenary features snakes. The garland suggests the real garlands that decorated shrines, and grapes grow on the lower slopes of the mountain, perhaps Vesuvius before it erupted.



Grapes were prominent not only in the garden of the ancient Pompeian but on the walls of his home as well. Paintings of the fruit, often in conjunction with animals, have been found at many excavated sites.







and sharpened "so that the vintager may not strip off the bunches of grapes with his hand, which causes no small part of the fruit to fall to the ground and the grapes to be scattered." Forty days before the vintage, terra-cotta dolia were treated with pitch. All wine-making equipment was thoroughly washed and dried. Then the wine cellar was cleaned and fumigated with pleasant odors, so that it would not smell moldy or sour.

Finally, sacrifices were offered "in greatest piety and purity" to the vessels of the wine press and to the deities of wine. Liber, the old Italic god of wine, who had become identified with Bacchus, and his female counterpart, Libera.

Columella thus helps us to picture the worship that took place in this vineyard at the outdoor altar in front of the huge lararium painting found on the garden wall.

Once the wine was fermented, it was put in amphorae. No doubt a quantity was consumed at the triclinium on the premises. The statue of a large gladiator with a shield protecting the small god Priapus, which stood on a pedestal near the triclinium, suggests that this vineyard was a favorite haunt of gladiators from the nearby amphitheater.

Less pretentious private gardens also had their grapevines. One of

At a wine shop, an elegant city dweller takes a sample of wine effered by the rustic wine dealer, while two employees pour off another cup from an amphora. Business activities in Pompeii were frequently depicted in paintings that show cupids engaged in human activities.



the most interesting is that of a family who lived above their shop. We excavated this garden and found both trees and grapevines, planted rather informally.

The many household items found at the open area at the rear of the garden suggest that the family gathered in this spot in the cool late afternoons and evenings to escape the heat of their stuffy second-floor dwelling. The open area at the east end of the garden, protected by the shop building, would be cool in the morning and was obviously left as a work area in the vicinity of the cistern.

Grapes were also raised in the nearby garden of the "House of the Ship Europa." This once noble house takes its name from a large graffito of a ship labeled Europa, which was found on an interior wall of the house when it was first excavated in 1957. By the time Vermins erupted it had been construct to commercial use. It was the only believed that the large tiper area at the rear of the house mas part of the commercial establishment, but our excavations in

1972 and 1973 proved that this area had been planted.

In the lower area at the rear of the garden, we found two distinct vegetable plots separated by furrows. The planting pattern in the rest of the lower garden was for the most part quite regular. There were single cavities fairly evenly spaced, with distinct depressions for holding water on each side. There were no depressions, however, in the space between the two rows that ran down the center of the garden. This space served as a path, not as elaborate as the arbored pathway we had found in the large vineyard, but adequate to give easy access to the vineyard and the two vegetable gardens.

The vine root cavities were 4½ Roman feet apart, slightly more than those in the large vineyard, but within the range recommended by the ancient agricultural writers. The cavities were slightly smaller (approximately 0.8 to 1.5 inches in diameter), and there was only one at each location, which indicates that the vines were not more than two years old, as the

workmen told me, and thus not old enough to be staked.

We were especially fortunate to find considerable carbonized plant material, which helped us identify what was raised in this garden. There were pieces of filbert shells, easily identifiable by the broad hilum, or seed scar, and the characteristic striations; a piece of carbonized fig; a fragment of carbonized almond with characteristic perforated surfaces; and perfectly preserved grapes, caramelized because of their high sugar content, which gave them a glassy appearance so that even the smallest fragment could be easily spotted. We even found grape seeds, readily identified by their bottle shape and their prominent markings. The large number of broad beans, or horse beans, including two with parts of strawberry weevils embedded in them, found in various places in this garden strongly suggests that other crops were interspersed among the vines and trees. The ancient Pompeian vine grower apparently did not take too seriously the warning of Pliny the Elder, who advised against planting beans and other garden vegetables near grapevines, which he claims have a sense of smell and are made sickly by certain plants.

The excavation of vineyards within Pompeii not only gives us our only detailed picture of the production and sale of one of the most important staples of Roman life, but it also raises broader questions of ancient city planning. In the past, scholars believed there was a shortage of land in the Italian cities of the early empire, a belief that is obviously contradicted by our discovery that valuable land within the city walls was planted in vines. As we continue to excavate and are able to identify the way in which the land was planted, our picture of land use in the ancient city gains in detail.

After receiving a ritual flogging, a bridal initiate into the mysteries of Dionysus dances in ecstasy. One room in the Villa of the Mysteries is decorated with scenes showing such initiation rites.





Waterfowl

Dry Continent

Australia's ducks and geese have evolved special strategies for survival

by L. Wayne Braithwaite

Australia is one of the world's driest continents. Its location, topography, and shape all contribute to a highly variable rainfall. More than half of its surface receives less than twenty inches of rain annually, and because of very high temperatures and subtropical high pressure systems of dry descending air, more than two-thirds of the continent has an annual evaporation that exceeds the annual rainfall.

This harsh climate has affected the day-to-day survival of Australia's waterfowl and the number



of species that inhabit the country. Although many species have special adaptations for survival and reproduction, the dry climate has probably been responsible for Australia's poor representation of the world's waterfowl population—nineteen breeding species compared with forty-two in North America.

The origins of these nineteen species are open to debate. Many, including the dabbling, or puddle, ducks, shelducks, and pochards, are closely related to species in other parts of the

world, suggesting a common origin and presumably fairly recent invasion from Asia. Others, such as the magpie goose, pink-eared duck, freckled duck, Cape Barren goose, and stiff-tailed musk duck show traits that are peculiar to Australia. Perhaps these originated some 50 to 100 million years ago in the giant southern continent of Gondwanaland, now broken up and forming parts of Africa, South America, Antarctica, India, and Australia.

The magpie goose, for example, has feet that are only

partly webbed, a hooked bill, and a successive molt of the primary wing feathers. The strong hooked bill has an obvious function-digging up spike rush bulbs, the staple dry-season food, in hard ground. The semiwebbed feet are an adaptation for walking long distances on dry plains and for clambering through the tall rushes of the birds' favorite swamps. And the successive wing molt assures that the bird will not become stranded in the dry season when most of the swamps dry up.





Pygmy geese, spoonbills, and egrets—species common to northern Australia—share a flooded area with cattle.

The rivers and their flood plains are the main habitat for waterfowl in Australia. Twelve river drainage systems divide the continent into four regions—Northern, Central, Murray-Darling, and Southern. Relatively few of the continent's rivers flow permanently. Most are seasonal or intermittent.

The Murray rises in the Great Dividing Range in the southeastern part of the country. On its westward-flowing course, it is fed by many tributaries, including the Darling River. Some of these tributaries, flowing from the north, receive water from summer rains: those flowing from the south, receive water from winter rains and melting snow. The volume of water thus entering the Murray River is sufficient to allow the river to flow continuously across the hot, semiarid plains before emptying into the Southern Ocean near the city of Adelaide. This drainage system, encompassing more than 400,000 square miles, is the country's principal waterfowl breeding and refuge area.

As a result of the seasonal rain and snowfall in the Great Dividing Range and its foothills, the different rivers of the Murray-Darling drainage system have seasonal flooding patterns. The variation in the seasons between the north and the south of the Murray-Darling region assures that drought, a yearly occurrence in Australia, will only occasionally affect the whole Murray-Darling region assures that drought, a yearly occurrence in Australia, will only occasionally affect the whole Murray-Dar-

In large colonies of black swans, such as this one near Canberra, the pair bond is usually weak. In areas where there are few swans, however, pairing is more often permanent. ling region. While drought is common somewhere on the continent so, too, is flooding. In the Murray-Darling system alone, for example, floods occur on one or another river in at least nine out of ten years.

Floods are essential to the waterfowl because they create a temporary but dynamic ecological succession of insect and plant foods. Thus, most inland waterfowl species have no fixed pattern of movements; they follow the floods, arriving and breeding as floodwaters are formed, and dispersing, sometimes to the very corners of the continent, to New Guinea or to New Zealand if drought conditions arise.

The gray teal and the pinkeared duck are two species that are well adapted to the use of inland floodwaters. Just how the birds find the water is unknown. But there are hints: In the dry inland particularly, ducks are often killed at night when they mistake corrugated steel roofs, which reflect the moon's light, for the surfaces of ponds and attempt to land on them. In some places these accidents happen so frequently that household cats have learned to identify the sound of a duck crashing, thereby considerably supplementing their normal diets. At high altitudes on moonlit nights, any large body of water can be seen at distances exceeding 100 miles. Ducks might move over long distances mainly by sight in a series of "hedge-hopping" flights from one body of water to the next.

Movement patterns of Australian waterfowl have not been thoroughly studied, but by far the most work on this subject has centered on the gray teal. One study by Harry Frith, an ornithologist and zoologist, concluded that gray teal invariably flocked to flood areas. As the floodwaters receded, these ducks moved on to more permanent waters. But during periods of intense droughtwhen even the stable waters disappeared-flocks broke up suddenly and dispersed randomly to remaining pockets of water. The distance the gray teal moved appeared to be limited only by the availability of suitable habitat.

Whereas dispersal for the gray teal involves the breakup of the major concentrations and the movement of individuals or small groups in different directions, flocks of pink-eared ducks remain much more cohesive during dispersal. Sometimes tens of thousands appear, seemingly overnight, on residual floodwaters, only to disappear in an equally mysterious way before the waters completely dry up. With the disappearance of a flock in one part of the country, there is sometimes a corresponding report of a new flock hundreds of miles from the initial sighting.

Wherever large flocks of these birds are found, the waters are usually teeming with the tiny crustaceans-copepods, cladocerans, or ostracods-that are their main food source. It is not certain how pink-eared ducks communicate with one another so that an entire flock can find such concentrated sources of food. The high-pitched whistle-often perceptible to the human ear more than half a mile away-emitted when the birds feed at night may be the answer. Any passing pinkeared duck would be attracted by the noise.

Each waterfowl species in Australia has a breeding season that reflects its adaptation to particular environmental circumstances. Nine species have habitat distributions confined to either the north or the south where habitat conditions vary on a seasonal cycle. These species breed at a fixed time each year. Another nine species are predominant either in southern Australia, extending into the north, or alternatively, in the north extending into the south. One species-the gray teal-tends to be evenly distributed north and

When examined on a continental scale, these widely distributed species breed throughout the year but only during favorable periods. On a regional basis, however, they tend to breed at approximately the same time as those species whose range is lim-



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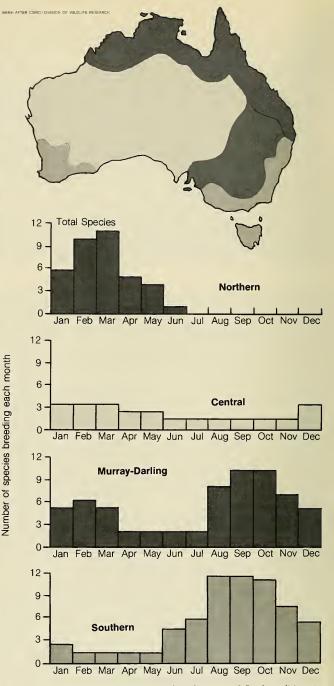
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Waterfowl breeding is geared to the onset of flood conditions in Australia's drainage systems, which divide the country into four regions. In the Central region where flooding is rare, breeding is constant. No more than 12 species breed at any one time.

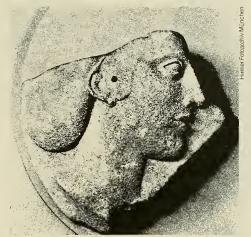
ited to the one particular region. Thus, in southeastern Australia, which includes the southern parts of the Murray-Darling system, most waterfowl breed from June to December—from the onset of Australia's winter to early summer. This is the time when the regular winter rains cause expansion and diversification of wetlands. In the northern parts of the Murray-Darling region, rain falls between November and May—Australia's summer. Here and on the northern coast of New

In the tropics in the far north of Australia, there are distinct wet summer and dry winter seasons, so breeding is restricted to the summer months of January to May. And in the very arid interior, the grazing Australian wood duck, the gray teal, and the pink-eared duck breed between December and March, when rain most commonly falls.

South Wales, waterfowl breed mostly during these months.

In addition to geography and climate, the type of habitat used by each species also plays a role in influencing the timing of breeding. In general those species that breed in seasonal or permanent swamps, lakes, or estuaries do so at about the same time each year. In the tropics these species include the magpie goose, two tree duck species, two pygmy goose species, and the Burdekin duck. In the south, regularly breeding species that inhabit permanent swamps include the pochard, the stiff-tailed diving ducks, the musk duck, and the blue-billed duck. A regularly breeding shelduck species inhabits coastal and inland lakes; the chestnut teal frequents estuaries and saline lakes; and the Cape Barren goose inhabits the islands between the continent and the island of Tasmania.

Other Australian waterfowl species, however, do not inhabit permanent or seasonal waters but may breed annually wherever their habitat is formed on a regular cycle. These species can be highly opportunistic in achieving this annual breeding cycle. The gray teal and the pink-eared duck show the highest degree of opportunism: both have a highly developed ability to time their breeding to flood conditions. These two species are



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Australian waterfowl, like most animals, breed when there is a suitable food supply both for breeding adults and for the growing young. But exactly how the birds know when to breed, achieving a synchrony between breeding and the appropriate food supply, is still a subject of much speculation. Studies so far indicate that Australian waterfowl have evolved two methods to solve the problem, either or both of which may be used by different species. The first method is the development of adaptations that allow the synchronization of breeding to events in the environment at any time of year. The second is the development of adaptations that regulate breeding to a set period each year in environments that tend toward seasonality.

The gray teal, the most common and widely distributed of Australia's ducks, begins courtship displays as soon as flooding occurs.

In the 1950s, Harry Frith became intrigued by the relationship between flooding on the inland rivers and the onset of sexual displays and breeding in different species of ducks, notably the gray teal and pink-eared duck. He concluded that sexual display was triggered by the changes in water levels brought on by flood conditions. Shallow floodwaters produce a succession of aquatic plants and insects, which provide ducklings with an abundant food supply. Research in this area is continuing on the gray teal, but we are still not certain of all the factors influencing the timing of breeding. We do not know if the gray teal actually perceives a change in water level, but we do know that the amount of available food is of major importance.

In one study, gray teal in an artificial water impoundment began breeding with the appearance of a suitable food supply even when there were no changes in water level. In another study, gray teal began intense courtship displays, together with the rapid development of reproductive organs, in response to the sight of heavy rain. This occurred in the absence of any other significant change in their captive environment. But in this study, the development of the reproductive organs ceased well before gonad maturation, the production of



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masses of sperm in males and ovulation in females. And in the absence of rains, captive gray teal always showed an apparent depression of reproductive organ development compared with their wild counterparts.

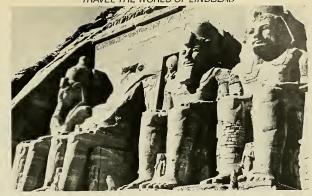
These effects, I think, have an ecological significance. They suggest that the gray teal is continually hypersensitive to small environmental changes. A ciency or disturbance so small that other species would not react to it has a strong influence on the gray teal's internal physiology. In times of rising water, the immediate environment is affected in many ways. The apparent response of the gray teal to the rising water may, in fact, be a response to these other changes such as food supply, availability of roosting and nest sites, proximity of these to a food source, and in dense populations, intraand inter-specific disturbances. Heavy rain, if it occurs, may simply have an additive influence, accelerating the response.

The intense communal sexual display seen in both captive and wild flocks of the gray teal also probably has the effect of accelerating and synchronizing reproductive organ development and breeding in all birds in each local population. Hence, with the passage of a flood peak and the creation of appropriate habitat conditions, a maximum number of birds breed, and each clutchsix to nine eggs-is produced and hatched within the shortest possible time (five to six weeks). The ducklings thereby have the maximum opportunity of utilizing an abundant but transient food source, and the risk of their becoming stranded in temporary lagoons is minimized.

Depending on the landform, flood conditions may last for less than a day in river catchments (too short a time to be of use to waterfowl) to more than a year on some of the very flat inland plains. A great many Australian rivers fail to eventually drain into the ocean, and when they flood, their waters spread out over the plains, filling swamps and temporary lakes that form natural drainage basins.

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Also at Bloomingdale's, Davison's, Foley's, Sanger-Harris, Strawbridge & Clothier, Woodward & Lothrop and 50 other fine department stores nationwide. Write for the store nearest you do the gray teal and pink-eared duck have the opportunity of successfully completing a breeding cycle. Where the floodwaters last more than a year, some birds may complete three or even four breeding cycles. And the young produced from the first broods may also breed successfully. One of the results of major floods, therefore, is a population explosion of ducks, particularly gray teal and pink-eared ducks. In times of drought, however, the absence of reproduction together with a high mortality rate, results in an equally pronounced diminution in numbers.

Much less than is known about the gray teal is known about the breeding of the pink-eared duck, mainly because the specialized diet of this species makes it difficult to maintain in captivity. We do know, however, that the male pink-eared duck has a unique attribute among birds. The testes resemble nothing so much as a short string of irregularly shaped and sized beads. Spermatogenesis is maintained in each bead, while the string itself is composed of in-

active seminiferous tubules.

This unusual morphology seems to be an extreme adaptation for life in the vast Australian interior. The testes of most waterfowl show an increase in total weight from 100 to 200 times between nonbreeding and breeding situations. The unusual shape of the pink-eared duck's testes is principally a device for conserving energy by minimizing the weight to be carried over long distances while maintaining a reproductive capacity for prompt response whenever the appropriate habitat is found.

The reproductive physiology of Australian waterfowl other than the gray teal and pink-eared duck seems to approach more closely the avian norm. Like the Northern Hemisphere mallard for example, the Australian black duck's annual physiological cycle—responsive to seasonal change and photoperiodicity—results in a limited period of sexual activity. This has a strong governing influence on the timing of breeding in temperate southern Australia.

This cyclical reproductive system has apparently evolved so the birds breed at the most appropriate time. In southern Australia, the black duck usually breeds in the rainy winter months. In tropical northern Australia, the black duck responding to the changed provisions of the



habitat, breeds during the rainy summer months.

The pochard, which inhabits the same areas in Australia as the black duck, probably responds to photoperiodic changes in the same way that the black duck responds to changed provisions of habitat. Species such as the shelducks, with ranges generally restricted to either the north or the south, may very well be limited in their breeding range through the specificity of their response to seasonal changes in daylight and the synchronization of this response with appropriate habitat conditions.

Major changes in the breeding range of some species occur where there is an alteration in habitat. The black swan, a predominantly southern species, is extending its range into northern Australia where water conservation programs have provided suitable habitat. In the north, breeding occurs at about the same time as in the south.

Although Australia has relatively few species of waterfowl there is a remarkable diversity. largely the result of the evolution of specialized response systems to the Australian environment. Changes in internal physiology, and in the ways in which different environmental variables are interpreted and responded to, enable species of Australian waterfowl to exploit a wide range of ecological situations.

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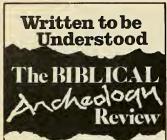
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INDIGENOUS AFRICAN ARCHITECTURE, by René Gardi. Van Nostrand Reinhold Co., \$32.50; 248 pp., illus.

If René Gardi's Indigenous African Architecture were to be evaluated solely on the merits of its photographs, the book would certainly rate as an exemplary achievement. The pictures are stunning and contribute greatly to realizing the author's goal of bringing his "readers closer to the African once again." More, of course, is required: namely, coherent knowledge of the many factors-social and cultural practices, available building materials, climate, building skills-that determine indigenous architectural styles. Furthermore, any discussion of this subject in the context of modern Africa is incomplete without reference to the effects of change on traditional values and forms. Indeed, change is a critical factor and must be considered beyond the mere assertion that Africa is losing her heritage and that is too bad. (For subtle examination of the impact of urban, nonagrarian society, the works of modern African novelists, such as Cyprian Ekwensi,

Chinua Achebe, Ayi Kwei Armah, and others, are most illuminating.)

Unfortunately, Mr. Gardi begins to lose points when we turn from the photographs to the text and to the relationship between the book's parts-text, drawings, structure. First of all the text is subordinate to the photographs, referring either to the particular settlement or the details being shown (straw walls and roofs, religious objects), rather than probing more deeply into the subject. As in a child's picture book, the photographs are used to carry the story "line"-suggesting not only a kind of visual continuity but a continuity of content as well. The concept is appealing on one level, but the price paid here is too great, for what needs to be understood by the reader cannot be received comprehensively through the illustrations alone. The settlements shown move from north to south, to the east and back to the

Chief's house in Bafut. The palace stands on a platform of basalt columns. The slender staves were formerly decorated with carvings.





north in a confusing way. Settlements that exist rather close to one another, but which differ in origin, building style, and social character, are shown in widely separated parts of the book, thus obscuring the interaction between them. An example would be Djenné, one of several permanent towns situated in areas otherwise occupied by nomads. These settlements have served as trading points along trans-Saharan routes and are often Muslim. Because such towns require a greater specialization of labor in their buildings, they represent a development in indigenous architecture somewhat different from either the nomads' tents or other compounds shown in the book.

Amos Rapoport, in House Form and Culture (Prentice-Hall, 1969), discusses various developmental stages of popular buildings, and the question of who builds is critical. He also cites the primacy of sociocultural forces in determining form even where materials are scarce. Christopher Alexander's Notes on the Synthesis of Form (Harvard University Press, 1964) distinguishes between "self-conscious and unselfconscious" building. (Self-conscious building is the work of craftsmen following tradition while unselfconscious building would be structures built in direct response to need.) A comparison between Djenné's architecture or that of the Muslim mosques and the nomad tents or more permanent self-built housing surrounding a mosque could have been most revealing.

In Architecture in Northern Ghana (University of California Press, 1969), LaBelle Prussin uses a strict comparative method in describing several villages. In each case, a cultural framework is defined through the consistent presentation of categories of information (cultural history, agricultural patterns, settlement mor-

phology, building techniques, and so on). By contrast, Gardi's comments are random and thus limit the reader's ability to understand why each group settled on a unique approach to the problem of shelter. Not only is his commentary superficial, but he offers little new information as in his discussion of the domed houses built by the Musgum people. Mr. Gardi's description very closely resembles that found in Prussin's L'Habitat au Cameroun. Perhaps the beauty of these structures is so compelling that it defies original description.

The style of the book is anecdotal—it reads something like a diary and is highly subjective. In his frequent asides, Mr. Gardi often compares what is being discussed with what appears to him to be a similar question in modern society, thus affording the reader considerable insight into his values.

In describing a compound that

can only be entered through the father's room, he writes: "There is no other way, and the teenaged daughter cannot come home late on a Saturday night scot free." One searches this statement in vain for a reflection of reality in a traditional African village. Other comments suggest Mr. Gardi's belief in the following: that women are mistaken in seeking fulfillment beyond the perimeters of child rearing; that less tension prevails in the villages he visited than in Western Europe; that the African is content with tradition, with a house "as much like the one he was familiar with as a child as possible"-this last in the face of peasant migrations to urban centers all over West Africa, not to mention the world. The mind-set represented by such attitudes is much like that encountered in a tourist. Although the tourist may note the existence of poverty and social tensions, his primary orientation is to ignore those things and focus on the reason for his visit-the uncovering of that which is exotic, different, and authentic. Like most tourists, he is finally more concerned with his own view of what

Africa has been and should re-

main (for his entertainment) than

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become. Hence, one of Mr.

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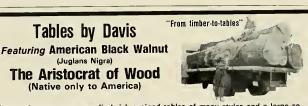
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Gardi's harshest comments is reserved for a student, a young Muktele who is one of the first in his family to become literate in French. The student, having new ways that the author does not like, is dismissed as being one of the uprooted. Whole villages of West Africans will often support or, at the very least, sanction the education of their young. Ultimately, Mr. Gardi is opposing their aspirations. Such attitudes as his are what lead Europeans into the position of seeking to defend "Africa" against the African.

Mr. Gardi concludes on the note that his work was not intended to be scholarly. That disclaimer notwithstanding, it does not seem unfair to demand that even an adult picture book construct bridges of affection and fa-





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miliarity between reader and subject based on understanding. The architecture of Africa, as with any other architecture, is a reflection of popular values and experiences. One must seek to grasp the essence of those values and experiences through serious and in-depth study in order to genuinely inform others.

J. Max Bond, Jr., is associate professor at Columbia University Graduate School of Architecture and Planning and a partner in Bond-Ryder Associates, Architects. For four years he lived in Ghana and taught at the University of Science and Technology in Kumasi.

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Oasis in China

Despite other revolutionary changes, traditional horticultural methods are still preferred to chemical compounds in the botanical gardens of one of the country's major cities

Behind the militant, highly organized, hard-working, and sometimes strident mainland Chinese society reported by many recent visitors from the West lies a peaceful and idyllic world not seen by many travelers. In various, quiet cases, some of the traditional forms of art and culture continue along their ancient pathways, unaffected by either changing ideology or revolutionary fervor.

During my second trip to China in 1972, my hosts, in deference to my title as professor of botany, guided my family and me to one such refuge, the Lung Hwa Botanical Garden on the outskirts of Shanghai. Never having heard of the Garden, I probably would not have chosen it from a list of places to visit. Yet I am grateful for the experience, for it provided a welcome respite from some of our more hectic ac-

tivities and an important emotional balance, against which other, more typical tourist attractions in the People's Republic of China could be measured.

As any big-city dweller can testify, the megalopolis can be a grim place in which to live. Concrete, asphalt, and brick, so essential to the manufacturing and business activities of the city, can easily warp the human spirit. Mankind seems to have a built-in need for some connection with greenery.

Revolutionary China has not forgotten or neglected this need, and wherever one travels-in a city, a suburb, or along a rural road-one is impressed by the massive planting of shade trees, windbreaks, and ornamental flowers. All the hotels and restaurants we visited were supplied daily with freshly cut flowers, and many had attractive potted plants sprinkled liberally throughout lounges, hallways, and fovers. The plague of plastic botany has not yet engulfed China, although I was distressed to note one massive and obviously synthetic centerpiece in the Peking Hotel, which contributed a jangling note to an otherwise unobjectionable décor.

The city of Shanghai has more than ten million inhabitants, which may possibly make it the most populous metropolis on earth. For administrative purposes, it is divided into ten central districts and ten suburbs. The Lung Hwa Botanical Garden, established in 1954, is in one of the city's ten suburbs. Supported entirely by Shanghai, Lung Hwa is a "synthesis garden," whose purpose it is to gather and propagate all of the ornamental plants likely to be needed by the municipality it serves. The plants it grows find their way into parks, small city plantings, flower markets that serve private houses, and ceremonial banquets.

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The majority of the jars were blown at the New England Glass Company in Cambridge, one of the most famous flint glass works of that century. After Agassiz's death, other jars were obtained from equally prestigious firms. This year, The Harvard Museum of Comparative Zoology (founded by Agassiz in 1860) decided to sell the antique jars. Each is now being photographed, numbered and cataloged. Ranging in size from less than two inches to over two feet, with fitted glass stoppers, they are elegant items of fine craftsmanship and authentic pieces of American scientific history. Upon request, we will mail you a free color booklet detailing the collection and its history. Prices range from five dollars to over two hundred dollars. Please write soon; these jars are not replicas and the collection is limited.

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ary Committee of the Garden, Su Chung-kai, who fairly oozed deep knowledge of plant lore and green-thumb expertise, this program seems able to provide an unending supply of trained horticulturists for the future.

Every Chinese botanical garden has its specialties, and Lung Hwa is no exception, concentrating on azaleas, orchids, dwarf trees, and slime molds. Some of the azaleas were in bloom during our visit. Varied in color and size of flower, pattern of growth, and texture of foliage, these plants showed evidence of long, careful selection and meticulous propagation. The tropical orchid house was as fine as most I have seen in major botanical gardens in many other parts of the world, and the flowering cactus collection-although not a Lung Hwa specialty-was unexpectedly large and variable. But the most remarkable exhibits were those of centuries-old, potted dwarf trees, and a unique collection of cultivated slime molds in "flower."

Bonsai, or the art of growing dwarf trees in small pots, is usually attributed to the Japanese. But my Chinese hosts were most emphatic in asserting that this art, like so many other aspects of Oriental culture, originated on the mainland and subsequently found its way to the Nipponese island kingdom. The Japanese did much to improve the ancient technique and also introduced it to the Western world, so they must receive some of the credit, but I am inclined to believe that, as with such other inventions as movable type, paper, and gun-powder, the Chinese were first with bonsai.

The most impressive dwarf trees at Lung Hwa were 150-yearold representatives of several species of pine and a century-old ginkgo. In all cases, the best dwarf specimens were produced by starting with a slow-growing variety and subjecting the plant to severe root pruning, the judicious pruning of branches, and the careful limitation of mineral nutrients. When placed in appropriate ornamental pots, the delicately sculptured dwarfs delight the eye. Bonsai is an art form worthy of great national pride, and that may be why the ChiHow do you learn about-How do you survive in it?

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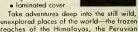
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nese are so eager to assert their priority of claim.

Even more striking than the exhibit of dwarf trees was the slime mold garden. These organisms, which have the characteristics of both plants and animals, are called Myxomycetes by botanists and Mycetozoa by zoologists. For most of their lives, the molds resemble a giant, jellylike amoeba, creeping slowly over their substratum of rotting leaves or wood. At an appropriate point in the life cycle, however, they form semierect organs that bear spores, which are then disseminated by wind or rain.

At Lung Hwa, these spores are carefully sown on moist birch logs, which are then incubated for months until the delicate spore-bearing organs mature. The result is a fragile fungus garden. Individual logs are displayed in homes, furnishing an unusual "floral" exhibit with about the same longevity as most fresh, cut flowers.

As a plant physiologist, I was struck by the fact that the Lung Hwa Garden made only sparing use of insecticides and fungicides. Most of the fertilizer was organic, although some nitrogenous chemicals were occasionally added to nursery plants. Herbicides and synthetic growth regulators were practically never employed. The healthy condition of plants and grounds was brought about by the application of considerable human labor. These impressive results made me wonder whether all our labor-saving devices and chemicals are really as much of a boon as they are represented as being.

I came away from Lung Hwa impressed not only by the beauty of its displays but also by the pride of its workers.

Columnist Arthur W. Galston teaches biology at Yale University.

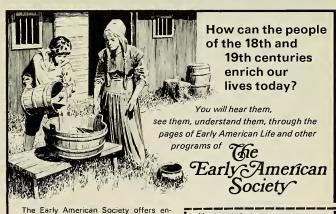
ERRATUM: In the Bios column "In Search of the Antiaging Cocktail," March, 1975, rotifers were erroneously referred to as a form of protozoan. Rotifers are multicelled organisms and are usually classified in the phylum Aschelminthes.



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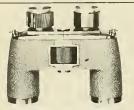
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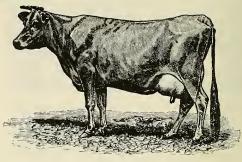
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Announcements



A model of the Pterosaur—meaning flying lizard—is mounted in the towered dome of the Roosevelt Rotunda of The American Museum of Natural History. The fossil remains of this creature, the largest ever to have flown, were recently discovered at Big Bend National Park in Texas. Pterosaur, which lived 160 million years ago, had batlike, hair-covered wings; a long, powerful neck and storklike jaw; and was a very efficient glider.

On Saturday, May 10, from 12:00 noon to 4:45 P.M., the Museum will celebrate Good Earth Day. In the Hall of the Birds of the World, the program of events will feature a trail of endangered species, research exhibits, and demonstrations by young people. In the Louis Calder Laboratory, the art of natural dyes and crafts from scraps will be shown. Organic and natural food cookery, nature and edible wild plants, a film of a monarch butterfly, and an environmental shadow puppet show will all take place in the People Center. And in the Education Hall, instructions will be given in how to milk a cow, how to make butter, the art of canoeing, and the proper way to plan for a trail walk or backpacking trip. For further details contact the Environmental Information Center, second floor.

The following programs will celebrate the Museum's exhibit of Contemporary African Arts:

At 2:00 P.M. in the Main Auditorium, an African Film Festival will feature *Mandabi* (The Money Order), on May 14 and 17; *Emitai* (Lord of the Sky), on May 21 and 24; *Jaguar* and *Bo*-

rom Sarret, on May 18; Black Girl and Tauw, on May 25.

Gallery Talks on Thursdays at 2:00 P.M. include: "Traditional Arts and Crafts of Africa," on May 15; and "Contemporary African Arts," on May 29.

The following slide talks will be held on Tuesdays at 2:00 P.M. in the Education Hall: "Ghanian Culture-Today and Yesterday," on May 20; and "Ethiopia-An Ancient Kingdom," on May 27.

On the weekend of May 17 and 18, the People Center will feature "Traditional Dances of Africa," "East African Bantu Music," and "Arts of Africa: Fabrics and Textiles." The Center is open from 12:00 until 4:30 P.M. on Saturday; 1:30 to 4:30 P.M. on Sunday.

In the Hayden Planetarium "Between the Planets" continues to explore the major planets and satellites of the solar system, as well as asteroids, meteoroids, and comets. Sky shows begin at 2:00 and 3:00 P.M. during the week, with more frequent showings on weekends. "Between the Planets" will run through June 30. Admission is \$1.75 for adults and \$1.00 for children.

A Legacy of Lepidoptera is an exhibit of the American naturalist Titian Ramsay Peale's original manuscript and illustrations of American Lepidoptera of the 1830s and Butterflies of North America of the 1870s. These volumes on butterflies are on display in the Rare Book Room, fourth floor of the Museum.

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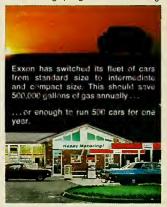


ity by 7.3 million kilowatt-hours. That is enough electricity to power 575 average-sized homes for one year.

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Cover: A cowboy from the 06 Ranch at Alpine, Texas, rides out to make the morning circle of the cattle. Photograph by Bank Langmore. This special illustrated supplement begins on page 32.

Authors



Throughout most of his career, Alan Berg has been involved with nutrition policy, planning, and programming, particularly as they relate to children. Currently on the staff of the World Bank, Berg spent the year 1966-67 in India as United States coordinator of the famine relief program, then stayed on for three more years to work with the Indian government in developing food and nutrition programs. His experiences in India are reflected in The Nutrition Factor, published by the Brookings Institution, where he was senior fellow for two years. The views expressed in "To Save the World from Lifeboats" are solely Berg's and do not necessarily reflect the policy of the World Bank.



An editor of the prestigious British scientific journal Nature, John Gribbin recently visited climatic research centers in the United States and Canada on a traveling fellowship for science journalists. Gribbin earned a Ph.D. in astrophysics from Cambridge University and is interested in the problem of communication across different scientific disciplines. He is coauthor of the book The Jupiter Effect, on earthquakes and earthquake prediction, and author of a book on the weather, scheduled for publication in the United States this year. Gribbin lives with his wife and young son in Brighton, England.

David R. Zimmerman, a freelance writer who specializes in ornithology, has investigated the techniques for increasing the populations of critically endangered birds of many countries. His report on management programs involving the peregrine falcon, Bermuda petrel, néné goose, Kirtland's warbler, and others will be published as a book, To Save a Bird in Peril, in August; "Vulture Restaurant" is adapted from one chapter. Zimmerman, a contributing editor with the Ladies' Home Journal, wrote "Captive Breeding: Boon or Boondoggle" for the December, 1974, issue of Natural History.



When Jan Harold Brunvand first went to Romania in 1970 to survey the country's rich folk culture, he was struck by the beautiful house decoration. Returning to the country in 1973, he undertook a detailed study of exterior house décor, concentrating on villages where traditional decorated houses are still being built. Brunvand, who is professor of English and Folklore at the University of Utah. is the author of a textbook, The Study of American Folklore, and of some eighty articles in scholarly journals. Among his published work on American folklore is a piece on the shaggy dog story.



While searching for coniferous tree fossils in the Santa Monica Mountains near Los Angeles, Mark S. Newton (left) came across a rare California mountain king snake. "That event suddenly brought home to me the history of this isolated range and emphasized its present ecological peril," he says. An associate professor of earth science at Los Angeles City College, Newton has been gathering data on the evolution of the natural environment of southern California. Newton hopes to devise computer programs capable of predicting shifts in patterns of biotic communities as functions of variations in geology, climate, and topography. Coauthor of "The Snake That Lost Its Habitat," Russell Smith is both an animal keeper in the reptile house of the Los Angeles Zoo and a candidate for a B.S. degree in zoology. With Mark Newton, he has explored all the canyons in the Santa Monica Mountains that seemed likely to sustain populations of the California mountain king snake. He will soon begin field work on the ecology of the endangered Pacific pond turtle and Hammond's garter snake. He believes such animals can be saved from extinction if the public is educated to appreciate rather than kill or collect them. Smith has also written papers on the captive breeding of the Blomberg toad and the Gila monster.

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To Save the World from Lifeboats

by Alan Berg

"Fixation on misguided labels is a luxury the world cannot afford"

People in intellectual and official circles have a penchant for coining new words or unearthing old ones as a means of dramatizing complex political issues. Capsule phrases from the past include domino theory. Iron Curtain, cold war, free world, and containment.

This year's fashions in political shorthand are the terms triage and lifeboat theory, both used to describe the world food problem. Triage refers to the medical disaster strategy of dividing casualties into three categories: those with superficial wounds, those badly injured but capable of surviving if given medical help, and those hopeless cases on whom limited medical manpower and supplies would be wasted.

Some people are now calling for a triage-type application in aid policies toward economically underdeveloped countries. This would involve a clear-cut listing of those that have enough food or foreign exchange to feed their people, Thailand and the oil-producing countries for example; those, such as Pakistan and the Philippines, with a manageable imbalance that could be corrected with food and financial assistance: and those countries that purportedly "can't be saved." In these countries, according to triagists like William and Paul Paddock, population has already outstripped agricultural potential; this, combined with "other divisive factors, makes catastrophic disasters inevitable." Bangladesh and several of the Sahelian countries have been given as examples.

The second phrase pictures affluent countries safely in a lifeboat, surrounded by a sea filled with poor nations, some treading water, some close to drowning. The lifeboat theorists suggest that the secure should be highly selective in tossing out life preservers; if everyone is helped, the lifeboat may sink of its own weight.

Unfortunately, catch phrases tend to give people the comfortable feeling of having grasped the whole picture with one or two words, avoiding in the process all the complexities, subtleties, and ambiguities that invariably surround human problems and that are, in fact, essential elements of such problems. When the issue involves projections thirty years into the future, the obvious dangers of oversimplification are magnified.

Another defect of political shorthand is that the graphic, catchy phrase has a tendency to stick even when it is wrong or, if originally appropriate, when bypassed by events. To yank the adhesive phrase from the consciousness is painful, requiring the stripping away of deeply ingrained positions with which an individual has identified and has been identified.

In the case of labels like triage and lifeboat, there are additional difficulties. For one thing, they divert attention from the more consequential aspects of the world food problem. We are inundated with photographic images of the starving in the Sahel. Ethiopia. and Bangladesh. While the famines in these areas are real and poignant, indeed tragic, they are

geographically isolated situations and affect only a small fraction of the populations in those countries.

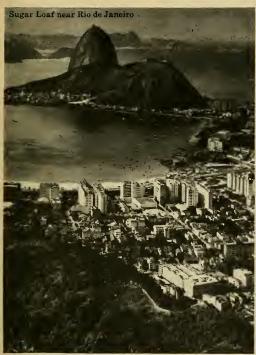
Far more important, but lost in the headlines and sensational pictures of the starving, are the numbers, thousands of times greater, who are being subtly debilitated by malnutrition. Because of the rising price of basic foodstuffs, the diets of the poor are smaller and less varied than they should be, and for many, less nutritious than they were in former years. As a result, millions of unobtrusive, unphotographed children in many low-income countries lack resistance to what would otherwise be relatively minor childhood diseases. Child mortality, already high, can be expected to increase appreciably in these countries, and of those who do survive, many will probably suffer physical and mental scars.

These are problems that will not disappear with what now looks like a favorable turn in weather in the disaster areas of last year, including the Sahel and most of South Asia. Nor will they disappear with the food available (at least as of this writing) from excellent, perhaps even record crops from the United States, China, and the Soviet Union. We have learned that a sufficient food supply is not enough. Serious nutritional deficiencies often persist because of distribution mechanisms incapable of reaching the poor and lack of understanding by some on how best to use the food resources already available to them.

Use of a triage or lifeboat label also distorts the reality of the situation. Countries are neither medically hopeless nor drowning. Al-

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Even an occasional bad harvest need not inevitably bring hunger and malnutrition. As most fooddeficit countries recognize, what is needed is increased emphasis on local agricultural production, population programs, and more efficient and equitable distribution of resources. Granted, given political and bureaucratic realities, these are not easy tasks and, in some cases, would require basic land, income, administrative, and political reform. The triage-lifeboat school, however, has apparently concluded that the governments and citizens of these countries are either unconcerned or incapable of taking the steps necessary to keep pace with their food needs: an imperious and ill-founded conclusion for outsiders to reach.

Furthermore, a triage-lifeboat label is dangerous because it not only describes a circumstance, albeit distorted, but it also affects the response. To some, the Malthusian image of triage offers an intellectual rationalization for inaction. Because the situation looks hopeless, triage can become a self-fulfilling prophecy. Do nothing, and for some countries disaster may be inevitable.

For the activists who want to

help, simplistic labels may lead to simplistic solutions. Many have suggested that by giving up one Big Mac a week or by cutting back on fertilizer for the azaleas, the world food problem will sort itself out. Not so. For the individual's act of deprivation to help the hungry abroad, there must be a direct program linking the reduced consumption of meat and fertilizer to formal assistance projects. No country has such a program.

More important than direct food transfer, however, is assistance for basic development programs that will increase local agricultural production, lower population growth rates, improve nutrition and health, and extend life expectancy. Reasonable assurance that children will survive may be a necessary precondition for lowering the birthrate, which in the long run is the crux of the food-population dilemma. The longer action is delayed, the larger will be the population base of future generations that must be fed. It is not in sirloin self-denial, but rather in the support of consequential development programs that individual energies can be most usefully mobilized to improve the human condition.

Returning to political catch phrases, there are still so many outdated shorthand misconceptions about development "basket cases" and "money down ratholes" that some people assume aid is a total waste. Accordingly, little public support is being mustered for development programs, and increasingly smaller budgets-especially in real terms—are being allocated in several affluent countries. Per capita aid received in low-income countries dropped in real terms by one-third over the past decade, a period in which the average per capita real income in the donor countries was increasing by one-half.

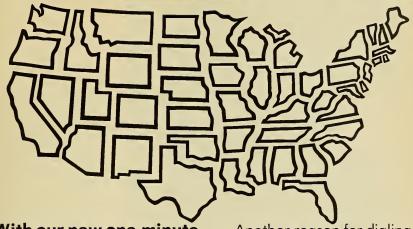
While it is true that all aid efforts have not been successful, some so-called basket cases of ten and twenty years ago are the economic success stories of today. In Korea, once considered financially hopeless, real income has doubled over the past decade, and GNP growth has averaged 10 percent a year, again in real terms. Despite all their problems, including substantial population increases, nearly all countries have more food per capita than they did

ten years ago. True, distribution is inequitable and shameful deprivations continue as wages of large portions of the population fail to keep pace with food prices. But without the successful aid efforts that doubled and tripled the production of crops in some countries, many more would be dying.

Finally, and most significantly, one cannot talk about triage without addressing its ethical implications. What does it mean to countries too poor to make the "aid list"? And what does it mean to those in affluent societies who are in a position to help? In the case of the former, triage, taken to its logical conclusion, will not eliminate problems, but will create bigger ones. A deliberate policy to withhold help to such countries as Bangladesh and Tanzania will probably lead to greater desperation, increased mortality, and a drag, if not a total brake, on development efforts. But the countries will not suddenly vanish. The reverberations of the social and political disruption that will accompany the misery are not likely to stop neatly at artificially drawn borders. As for those who would have been in a position to help, the conscious adoption of a policy of triage would constitute a basic deviation from what we have long considered moral responsibility to say nothing of human decency. It is not an attractive prospect.

Those of us who work with international nutritional issues are frequently asked which among the many forces at play-rises in food prices, aberrations of the weather, fertilizer shortages, oil constraints-should be the focus of greatest concern. Although all are important, the trend I find most disturbing and most significant in the last year is the increasing numbness to the problems of those in need—particularly on the part of those who in the past have been concerned. Continuation of this trend, something triage talk reinforces, has ominous implications.

With political labels, especially those like triage and lifeboat, which distort and distract, the turn of the good phrase often becomes the turn of the screw. Given the penalties for delaying a major attack on the food-population problem, fixation on misguided labels is a luxury the world cannot afford.

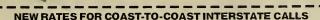


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Whither the Weather?

by John Gribbin

The global climate seems to be cooling, which may forebode a drastic cut in the production of food

Despite the "green revolution" of the 1960s, world food reserves, in the face of increasing population, have reached a critical hand-to-mouth state. According to some predictions, major famines may be only a few years away. This situation is disturbing enough in itself, but we now also have a wealth of evidence that the pattern of the world's climate is changing—and not for the better. Pessimists say this change could be the final straw that will break the back of world food supply systems.

Until very recently, when climatologists spoke of a new ice age being "just around the corner," they meant that slow changes over thousands of years could produce that result. And only fifty years ago, even the experts believed that climate was, by and large, unchanging over any time scale relevant to our present civilization. But it has now become clear that climate can respond both rapidly and significantly to small changes in the variable factors that combine to produce the global circulation pattern of the atmosphere.

This situation need not be a great problem in itself. Over the past few hundred years, there have been long periods during which the climate worldwide was much less equable than it is today without causing the downfall of civilizations. The present concern arises from the possible impact of a climatic shift at a time when our society lacks substantial reserves of either food or suitable, prepared agricultural land.

The World Meteorological Or-

ganization was one of several international bodies that drew attention to this problem in 1974. Since 1972, vast reserves of stored grain have been consumed, and almost all the eligible idle land in North America—the granary of the world—has been returned to active production. Currently, we have only marginal reserves of grain and practically no prepared spare land on which to grow more. In addition, the actual production of grain each year depends to a very large extent on the weather.

The consequences of these conditions have been clearly demonstrated in the past year or two by famine in the sub-Saharan Sahel region of Africa, in Ethiopia, and in parts of the Indian subcontinent. The extent to which climatic factors are responsible for these troubles is still being discussed. But there is no doubt that overgrazing intensified the famine in the Sahel, so that man's own actions are at least partly to blame for the problem in that area, irrespective of any natural changes in climate.

According to some experts, man's activities may even be one of the agencies that is causing changes in the weather. Reid Bryson, of the University of Wisconsin in Madison, for example, believes that man-made dust in the atmosphere is contributing to a global cooling. A cooler earth, predicted by some climatological theories, is, in turn, associated with the kind of rain pattern that has led to recent famines. Bryson's position is based on two related assumptions, neither of which is unambiguous.

First, it is assumed that the earth is cooling down. But is it? The most objective answer that climatologists can give is that all the evidence they have points in that

direction. Many scientists admit, however, that the evidence is not as convincing as they would like it to be. The snag is that global mean temperatures are calculated on the basis of measurements made at observation stations scattered around the world—but these stations can only provide information on conditions in their immediate neighborhoods.

Most of the measurements come from stations in the industrially developed countries of the Northern Hemisphere. While these stations indicate an average downward trend in temperature over the past thirty years or so, not all stations show a cooling trend. There are several recording stations in Canada that show an upward trend in temperature over the past few years, although other stations in North America, including those in the Great Plains (an important area for wheat production), show cooling. In general, maximum cooling has taken place at about sixty degrees north and south latitude, with less cooling at the poles and mid-latitudes, and a slight warming in the tropics. Few data have hitherto been available from the oceans (at least until the recent development of satellite monitoring of sea temperatures), but there are some ship data that show a steady significant cooling of the North Atlantic.

The second of Bryson's assumptions offers a reason why this cooling may be real and suggests that it will not be reversed in the immediate future. The explanation is that man-made pollution in the form of dust has penetrated the atmosphere in sufficient quantity to screen out some of the radiation that previously reached the earth, thereby cooling the air. But here again there is no uniform agree-

ment that the total level of dust in the atmosphere has, in fact, increased over the past ten years. According to John W. Firor, execter for Atmospheric Research in Boulder, Colorado, dust levels in the atmosphere near cities have dropped, while those in rural regions have risen. Climatologists and meteorologists cannot decide whether such a pattern will cause the world to get cooler or warmer.

Another climatic effect induced by human action is the release into the atmosphere of carbon dioxide produced by the burning of fossil fuels. The presence of this compound changes the way the atmosphere transfers heat back to space. In simple terms, radiation from the sun penetrates the atmosphere to the earth's surface without hindrance, but the heat radiated from the ground back to space cannot escape as easily when increased amounts of carbon dioxide are present in the atmosphere. This trapping of heat-the greenhouse effect-caused by rising amounts of CO2 in the atmosphere, could lead to a general warming of the earth. But by how much and how quickly? Once again, opinions differ greatly. J. S. Sawyer, of the United Kingdom Meteorological Office, for example, says that even an exponential growth rate in the use of fossil fuels would only cause an increase in worldwide temperatures of a fraction of 1° C. by the end of this century. Since that kind of growth rate would use up all available fossil fuel by that date, there would be nothing further to worry about in terms of atmospheric heating.

If the world should, in fact, get warmer, evaporation from the oceans could produce more clouds,



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which could reflect away more of the sun's heat, producing a cooling effect that might, in turn, stabilize or reverse the situation. The following long-range question, therefore, remains to be answered definitively. Are man's activities causing the world to heat up, get colder, or are they having no effect at all? Neither of the extremes is likely, and on the basis of the best evidence we have to date, the most sensible course of action is probably to address ourselves first to natural climatic changes, leaving the possibilities of man-made effects until such time as we understand more about them.

The Wisconsin group headed by Bryson is highly respected by other climatologists for its investigation of past climates. This research has recently made dramatic strides by using sophisticated techniques based on pollen analysis. The types of pollen laid down in sediments depend on the plants growing in a particular area, and that depends on the local climate. By studying pollen variations in layers of sediment from, say, a core drilled in a lake bed, it is possible to get a good idea of how climate has varied in the past.

This research shows what Bryson calls "sharp" changes in climate: these can occur within about twenty years. Sharp in this context is defined by Bryson as meaning that the world can seemingly switch from an interglacial type of climate, like the present one, to a full ice-age climate in just over 100 years. The latest study by Bryson's group concentrates on pollen analysis of a continuous core of lake sediment laid down over a period of 9,000 years. This is one of the best climatic records of its kind available today. When the full results of the analysis are made known, they will provide us with a better understanding of rapid changes in local climate.

The results of these studies would be interesting, but not particularly worrisome, if we had plenty of food and land and if there were no evidence that the climate might now be changing gear in much the same way it has so often done in the past. But none of these provisos hold. The food situation has already been mentioned. As far as present-day climatic changes are concerned, a key piece



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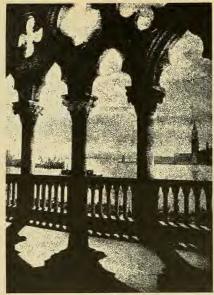
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of evidence comes from a study of the growth of snow and ice cover in the Northern Hemisphere in recent years. This investigation, made possible by the advent of satellite photography, was carried out by George and Helena Kukla, working in the CLIMAP research group at the Lamont-Doherty Geological Observatory of Columbia University. The study has such farreaching implications that it is worthy of more than passing mention. But first, it is necessary to have some idea of how changes in the over-all circulation pattern of the atmosphere tie in with temperature changes.

The climatic zones of the world depend basically on latitude; their characteristics are determined primarily by the annual amount of radiation received from the sun. This amount is high in low latitudes and low at the poles. Convection, however, carries air from the warm Equator to the cold poles, tending to smooth out differences. Circulation in the Southern Hemisphere should, by and large, be a mirror image of that in the Northern Hemisphere, but this

is not the case.

One key to the difference in climate in the two hemispheres is the relative size and dynamics of the high-pressure regions in each hemisphere and their surrounding belts of low pressure, which are centered on the poles. If the high-pressure regions expand, climatic zones are to some extent pushed toward the Equator, bringing drier air to some latitudes and shifting the rainfall belts. According to one explanation, expansion of the area of high-pressure cold air over the North Pole is what produced the recent droughts in India and in the Sahel region of Africa along the southern border of the Sahara. Rain in the Sahel averaged only about four inches for five meteorological stations monitored between 1957 and 1970-a change from previous rainfall that Bryson rightly calls "a disastrous decline for an arid region."

The same change in high-pressure area could also explain why there has been increased rainfall at the northern margin of the Sahara but decreased rainfall over much of Europe and Britain.

How might such air circulation changes be related to the growth of

snow and ice cover in the north? According to climatic modelers, the kind of shift in rainfall zones that has actually taken place would be expected if the earth were cooling and a so-called weak circulation pattern were established. Known changes in rainfall thus tie in with the idea that the earth has indeed been cooling down lately. But the study carried out by the Kuklas produces remarkable evidence suggesting a direct link between the growth of snow and ice cover and changes in atmospheric circulation.

Although the approach used by the Lamont team is essentially simple, it depends on a sophisticated, recent technological development-satellite photography of the earth. What the Kuklas did was study the changes in snow and ice cover that show up in successive satellite photographs. In order to differentiate snow from clouds, given points over snow and ice fields were photographed repeatedly for five consecutive days, and the pictures were then analyzed by computer. The darkest photographic images were considered to show ground; the lighter images depicted snow or ice fields that lasted at least five days. The results were then checked against ground information and charted. Areas of highly reflecting snow and ice are, of course, of great importance in determining how much heat the earth reflects into space. Changes in the extent of the snow and ice cover, in turn, produce changes in the total heat balance of the earth over the years.

To understand why snow is so important, it must be realized that more than 20 percent of the solar radiation that reaches the earth is reflected by vegetated land and 5 to 10 percent is reflected by calm seas. Total reflection, however, increases to 60 to 80 percent when snow covers the land or ice covers the sea. And, in addition to the solar light lost to space through reflection before it can warm the ground, snow and ice can lower temperatures because of the heat required to melt them in the spring. The calories needed to melt a given amount of ice are enough to raise the temperature of an equivalent amount of water from 0° C. to 80° C.

The total global extent of snow



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and ice can vary greatly from year to year. The annual average in the Northern Hemisphere increased by almost 12 percent during 1971. The average taken over the previous four years was about thirteen million square miles: the running twelve-month average since 1971 has remained at about fourteen and a half million square miles but has begun to diminish slowly during the past few months.

Four snow cover seasons-referred to as SCs-can be recognized from satellite snow cover maps of the Northern Hemisphere by applying the following arbitrary but straightforward definitions: SC-winter is that part of the year when more than twenty million square miles are covered by snow or ice; SC-spring is the time when the cover is melting down from twenty million square miles to about five million square miles; SC-summer is the period for which the cover is less than five million square miles: and SC-fall, logically enough, covers the buildup of snow and ice from five million square miles back to twenty million square miles.

The Kuklas' study, which began with calendar year 1967 and is still going on, showed that the snow and ice pack formed earlier in the fall and lasted longer into the spring in some years than others. From 1967 to 1970, SC-fall started on October 5 or October 10, but in 1972 it began on September 17 and in 1973 it started on September 20. The corresponding dates for the start of SC-spring (with the exception of 1967, for which the study includes no date) are: 1968. March 9: 1969, March 10: 1970, January 30; 1972 and 1973, March 15

The exact dates of SC-spring and SC-fall can provide a useful index to the changes in the over-all effect of snow and ice on the earth's heat balance, just as the average cover throughout the year provides important information about the global weather situation. In general, increased snow and ice cover occurs conjointly with the kind of weak circulation that may be responsible for the recent climatic troubles of the Northern Hemisphere, although it is still far from clear which is cause and which effect. Does more snow and ice cause the weaker circulation or







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does the weaker circulation pattern allow the buildup of more snow and ice?

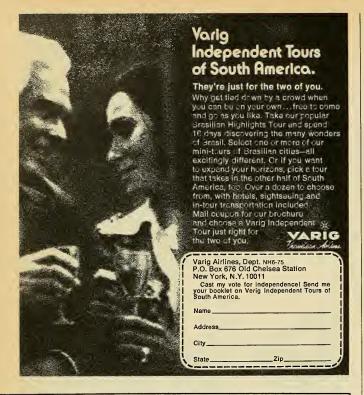
Either way, during a full ice age the cover of the Northern Hemisphere would be about twenty-five million square miles-almost twice the annual average in the years just before 1971. In other words, the increase of almost one and a half million square miles between the averages for 1967 to 1970 and for 1971 to 1973 corresponds to almost one-tenth of the difference between the situation in 1970 and a full ice age. That does not mean, however, that we must expect a new ice age within the next decade. Since 1971, the evidence is that the new average of fourteen million square miles of snow and ice cover has begun to decrease slowly. But the speed and scale of this change provide plenty of food for thought, especially in view of Bryson's work, which indicates how quickly even more dramatic changes seem to have occurred in the past.

It should be remembered that this change in the snow and ice cover pattern occurred only a year before 1972—a time of strikingly anomalous atmospheric circulation that seems to have tipped the balance of rainfall against the farmers of the Sahel. In addition, and to an extent that is only now becoming clear, the farmers of North America, whose grain and soybean crops are so vital to world food supplies, seem also to have been affected. These anomalous weather conditions persisted into 1974.

Droughts in Africa are one thing—after all, agriculture has been a marginal occupation in the Sahel for as long as modern civilization has been around. But why should these recent, subtle changes in climate and atmospheric circulation cause problems in the more equable regions farther north? The kind of effect that is causing concern is only a decline of a degree or two in average temperatures over, perhaps, a decade, with a seemingly modest concomitant redistribution of rainfall patterns.

Unfortunately, any decline in average temperatures, when combined with increased frequency of weather anomalies, can adversely affect crops in a number of significant ways. Together, they increase the likelihood of late frosts in the





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spring, early frosts in the winter, and unusual rains at harvesttime. In other words, such shifts in climate cut into the growing season from both ends and also change its characteristics. One fascinating example of how sensitive agriculture can be to small changes in the weather has recently been provided by evidence that correlates fluctuations in agricultural output with changes in sunspot activity.

Sunspots are associated with the production of the charged particles of the solar wind, which streams across space. It is deflected by the earth's magnetic field in such a way as to be focused on the polar regions of the atmosphere. Toward the middle of the last century it was discovered that the number of sunspots reaches a maximum about every eleven years in what is known as the solar cycle. The idea that the solar cycle of sunspots can affect the weather is, however, a relatively new concept, although how the interconnection operates is still not clear.

The peak of world food reserves in 1969 amounted to 19 percent of one year's consumption; by 1974, reserves were down to only 7 percent of annual consumption. Since weather variability can amount to 10 percent of annual consumption, one bad year could wipe out all food reserves. This disturbing information encouraged a group of scientists working at the Appleton Laboratory in England, an establishment that does astronomy and space research, to carry their investigation of a relationship between sunspots and the weather one stage further and search for any evidence they could find linking sunspots with agricultural productivity.

Taking world wheat production figures for the period from 1949 to 1973, it was found that production was greater in 1958 than in each of the next five years; in 1968, it was greater than in any of the next four years. It also happens that sunspot maximums occurred in 1957 and 1968. Is that just coincidence? It was found, additionally, that in 1954, a year of sunspot minimum, wheat production was lower than in any of the two preceding or succeeding years. The 1954 crop in North America alone was the smallest of any year for which records are available, and the average crop during the five preceding years was 25 percent greater than the 1954 crop.

Figures from several individual countries show the same kind of fluctuation of agricultural production in step with sunspot variations. In Canada, for example, average wheat production from 1967 to 1969, the years centered on the 1968 sunspot maximum, was 27 percent greater than during the four years from 1970 through 1973. In the Northern Hemisphere. in general, wheat production seems to be significantly enhanced as the sunspot maximum approaches and reduced at times of sunspot minimum.

Curiously, the reverse apparently takes place in the Southern Hemisphere. In Argentina, for instance, booms in the wheat crop occur at times of sunspot minimum. Thus, 1954 and 1964 were very good crop years. In Australia, the year 1957, close to a sunspot maximum, was a particularly poor year for wheat; the average production during the preceding eight years was 84 percent greater than in 1957. But this seeming balance between north and south is of no great practical help because most of the land area of the globe and most food production is concentrated in the Northern Hemisphere.

Bizarre though the idea may seem, a possible link between the sun's activity and agricultural productivity nevertheless provides about the only bright prospect in the currently gloomy outlook for achieving a balance between food production, population, and climate. What is desperately needed is a run of good weather years to provide us with an opportunity to grow more food than is required for immediate consumption. Given that chance, world food reserves could be built up to a point that would enable us to cope with another run of bad years.

If the sunspot effect is valid, it will be acting over the next four or five years to improve the prospects for farmers. With luck, we could then rebuild our global food reserves before the sunspot cycle dips again in the early 1980s. Our technology is certainly up to the task. The question is whether the necessary political will and wisdom exist.

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Racism and Recapitulation

Scientific theories and racist attitudes are strange, but familiar, bedfellows

The adult who retains the more numerous fetal. [or] infantile . . . traits is unquestionably inferior to him whose development has progressed beyond them. Measured by these criteria, the European or white race stands at the head of the list, the African or negro at its foot.

D.G. Brinton, 1890

On the basis of my theory, I am obviously a believer in the inequality of races. . . In his fetal development the negro passes through a stage that has already become the final stage for the white man. If retardation continues in the negro, what is still a transitional stage may for this race also become a final one. It is possible for all other races to reach the zenith of development now occupied by the white race.

L. Bolk, 1926

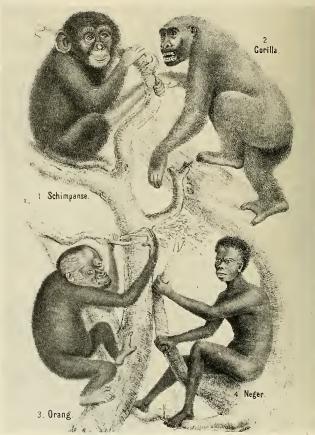
Blacks are inferior, Brinton tells us, because they retain juvenile traits. Blacks are inferior, claims Bolk, because they develop beyond the juvenile traits that whites retain. I doubt that anyone could construct two more contradictory arguments to support the same opinion.

The arguments arise from different readings of a fairly technical subject in evolutionary theory: the relationship between ontogeny (the growth of individuals) and phylogeny (the evolutionary history of lineages). My aim here is not to explicate this subject but rather to make a point about pseudoscientific racism. We like to think that scientific progress drives out superstition and prejudice.

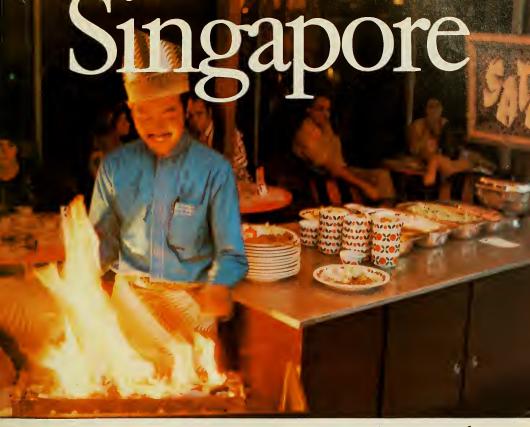
Brinton linked his racism to the theory of recapitulation, the belief that individuals, in their own embryonic and juvenile growth, repeat the adult stages of their ancestors—that each individual, in its own development, climbs up its family tree. (To supporters of recapitulation, the embryonic gill slits of human fetuses represent the adult fish from which we descended. And, in the racist read-

ing, white children will pass through and beyond the intellectual stages that characterize adults of "lower" races.) During the late nineteenth century, recapitulation provided one of the two or three leading "scientific" arguments in the racist arsenal.

By the end of the 1920s, however, the theory of recapitulation had utterly collapsed. In fact, as I argued in last month's column, an-



The 1874 edition of Ernst Haeckel's Anthropogenie contains this racist illustration of evolution.



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thropologists began to interpret human evolution in precisely the opposite manner. Bolk led the movement, arguing that humans evolved by retaining the juvenile stages of our ancestors and losing previously adult structures-a process called neoteny. With this reversal, we might have expected a rout of white racism: at least, a quiet putting aside of previous claims; at best, an honest admission that the old evidence, interpreted under the new theory of neoteny, affirmed the superiority of blacks (since the retention of juvenile features now becomes a progressive trait). No such thing happened. The old evidence was quietly forgotten, and Bolk sought new data to contradict the old information and support once again the inferiority of blacks. With neoteny, "higher" races must retain more juvenile traits as adults; so Bolk discarded all the embarrassing "facts" about juvenile traits of blacks once used by recapitulationists and enlisted the few juvenile features of adult whites in his

support.

Clearly, science did not influ-

ence racial attitudes in this case. Quite the reverse: an a priori belief in black inferiority determined the biased selection of "evidence." From a rich body of data that could support almost any racial assertion, scientists selected facts that would yield their desired conclusion according to the theory currently in vogue. There is, I believe, a general message in this sad tale. There is not now and there never has been any unambiguous evidence for the genetic determination of traits used to make racist distinctions (differences between races in average values for brain size, intelligence, moral discernment, and so on). Yet this lack of evidence has not forestalled the expression of scientific opinion. We must therefore conclude that this expression is a political rather than a scientific act-and that scientists tend to behave in a conservative way by providing "objectivity" for what society at large wants to hear.

To return to my story: Ernst Haeckel, Darwin's greatest popularizer, saw great promise for evolutionary theory as a social weapon. He wrote:

Evolution and progress stand on the one side, marshaled under the bright banner of science; on the other side, marshaled under the black flag of hierarchy, stand spiritual servitude and falsehood, want of reason and barbarism, superstition and retrogression. . . . Evolution is the heavy artillery in the struggle for truth; whole ranks of dualistic sophism fall before [it] . . . as before the chain shot of artillery.

Recapitulation was Haeckel's favorite argument (he named it the "biogenetic law" and coined the phrase "ontogeny recapitulates phylogeny"). He used it to attack nobility's claim to special statusare we not all fish as embryos?-and to ridicule the soul's immortalityfor where could the soul be in our embryonic, wormlike condition?

Haeckel and his colleagues also invoked recapitulation to affirm the racial superiority of northern European whites. They scoured the evidence of human anatomy and behavior and used everything they could find from brains to belly buttons. Herbert Spencer wrote that "the intellectual traits of the uncivilized . . . are traits recurring in the children of the civilized." Carl Vogt said it more strongly in 1864: "The grown up Negro partakes, as regards his intellectual faculties, of the nature of the child. . . . Some tribes have founded states, possessing a peculiar organization, but, as to the rest, we may boldly assert that the whole race has, neither in the past nor in the present, performed anything tending to the progress of humanity or worthy of preservation." And the French medical anatomist Etienne Serres really did argue that black males are primitive because the distance between their navel and penis remains small (relative to body height) throughout life, while white children begin with a small separation but increase it during growth-the rising belly button as a mark of progress.

The general argument found many social uses. Edward Drinker Cope, best known for his "fossil feud" with Othniel Charles Marsh, compared the cave art of Stone Age man with that of white children and "primitive" adults living today: "We find that the efforts of the earliest races of which we have any knowledge were similar to



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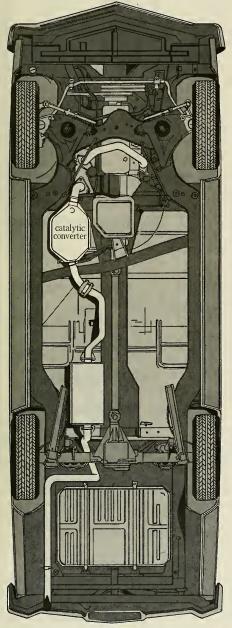


those which the untaught hand of infancy traces on its slate or the savage depicts on the rocky faces of hills." A whole school of "criminal anthropology" branded white wrongdoers as genetically retarded and compared them again with children and adult Africans or Indians: "Some of them [white criminals]," wrote one zealous supporter, "would have been the ornament and moral aristocracy of a tribe of Red Indians." Havelock Ellis noted that white criminals, white children, and South American Indians generally do not blush.

Recapitulation had its greatest political impact as an argument to justify imperialiam. Kipling, in his poem on the "white man's burden," referred to vanquished natives as "half devil and half child." If the conquest of distant lands upset some Christian beliefs, science could always relieve a bothered conscience by pointing out that primitive people, like white children, were incapable of self-government in a modern world. During the Spanish-American War, a major debate arose in the United States over whether we had a right to annex the Philippines. When anti-imperialists cited Henry Clay's contention that the Lord would not have created a race incapable of self-government, Rev. Josiah Strong replied: "Clay's conception was formed before modern science had shown that races develop in the course of centuries as individuals do in years, and that an underdeveloped race, which is incapable of self-government, is no more of a reflection on the Almighty than is an undeveloped child who is incapable of self-government." Others took the "liberal" viewpoint and cast their racism in the paternalist mode: "Without primitive peoples, the world at large would be much what in small it is without the blessing of children. . . . We ought to be as fair to the 'naughty race' abroad as we are to the 'naughty boy' at home."

But the theory of recapitulation contained a fatal flaw. If the adult traits of ancestors become juvenile features of descendants, then their development must be speeded up to make room for the addition of new adult characters onto the end of a descendant's ontogeny. With

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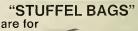
the rediscovery of Mendelian genetics in 1900, this "law of acceleration" collapsed, carrying with it the whole theory of recapitulation-for if genes make enzymes and enzymes control the rates of processes, then evolution may act by either speeding up or slowing down the rate of development. Recapitulation requires a universal speeding up, but genetics proclaims that slowing down is just as likely. When scientists began to look for evidences of slowing down, our own species took the limelight. As I argued in last month's column, humans have, in many respects, evolved by retaining juvenile features common to primates and even to mammals in general-for example, our bulbous cranium and relatively large brain, the ventral position of our foramen magnum (permitting upright posture), small jaws, and relative hairlessness.

For a half century the proponents of recapitulation had collected racial "evidence"; all of it argued that adults of "lower" races were like the children of the white race. After the collapse of the theory of recapitulation, the supporters of human neoteny still had these data. An objective reinterpretation should have led to the admission that "lower" races are actually superior; for as Havelock Ellis (an early supporter of neoteny in 1894) wrote: "The progress of our race has been a progress in youthfulness." Indeed, the new criterion was accepted-the more childlike race would henceforward wear the mantle of superiority. But the old evidence was simply discarded, and Bolk scurried about for some opposite information to prove that adult whites are like black children. He found it, of course (you always can if you want to badly enough): adult blacks have long skulls, dark skins, strongly prognathous jaws, and an "ancestral dentition"; while adult whites and black babies have short skulls, light (or at least lighter) skins, and small, nonjutting jaws (we'll pass on the teeth). "The white race appears to be the most progressive, as being the most retarded," said Bolk. Havelock Ellis had said much the same in 1894: "The child of many African races is scarcely if at all less intelligent

than the European child, but while



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the African as he grows up becomes stupid and obtuse, and his whole social life falls into a state of hidebound routine, the European retains much of his childlike vivacity."

Lest we laugh at these statements as lapses of a bygone age, I note that the neotenic argument was invoked in 1971 by a leading genetic determinist in the I.Q. debate. H. Eysenck claims that African and black American babies display faster sensorimotor development than whites. He also argues that rapid sensorimotor development in the first year of life correlates with lower I.Q. later. This is a classic example of a potentially meaningless, noncausal correlation: suppose that differences in I.Q. are completely determined by environment; then, rapid motor development does not cause low I.Q.-it is merely another measure of racial identification (and a poorer one than skin color). Nonetheless, Eysenck invokes neoteny to support his genetic interpretation: "These find-

ings are important because of a

very general view in biology according to which the more prolonged the infancy the greater in general are the cognitive or intellectual abilities of the species."

But there is a hooker in the neotenic argument, one that white racists have generally chosen to ignore. It can scarcely be denied that the most juvenilized of human races are not white, but mongoloid (something the American military never understood when it claimed that the Vietcong were manning their armies with "teen-agers" many of whom turned out to be in their thirties or forties). Bolk darted around it; Havelock Ellis met it squarely and admitted defeat (if not inferiority).

If the racist recapitulationists lost their theory, perhaps the racist neotenists will lose on facts (even though history suggests that facts are simply selected to fit prior theories). For there is another embarrassing point in the data of neoteny—namely, the status of women. All was well under recapitulation. Women are more childlike in their anatomy than men—a

sure sign of inferiority, as Cope argued so vociferously in the 1880s. Yet, in the neotenic hypothesis, women should be superior by the same evidence. Again, Bolk chose to ignore the issue. And again, Havelock Ellis met it honestly to admit the position that Ashley Montagu later championed in his treatise on "the natural superiority of women." Ellis wrote in 1894: "She bears the special characteristics of humanity in a higher degree than man. . . . This is true of physical characters: the largeheaded, delicate-faced, smallboned man of urban civilization is much nearer to the typical woman than is the savage. Not only by his large brain, but by his large pelvis, the modern man is following a path first marked out by woman." Ellis even suggested that we might seek our salvation in the closing lines of Faust:

> Eternal womanhood Lead us on high.

Stephen Jay Gould teaches geology at Harvard University.



Vulture Restaurant

by David R. Zimmerman

What's good for these birds is good for the countryside

The day's first diners are already eating, perched on the head of a chestnut horse that lies stiff in death. They are jaunty, black-and-white birds—magpies. Each stands in turn on the dead horse's cheek or brow and pecks smartly downward into the eye socket, then tilts its head back and swallows with evident relish before yielding to the next in line.

The sun, just risen above a nearby peak, frosts the pastoral green valley in pink. The location: the province of Navarre in the north of Spain, twenty miles south of France. The flat, dry plain stretching up from the south erupts here into the foothills of the Pyrenees. The first huge column of rock rises suddenly some 2.500 feet above the plains. It gives its name, Monreal. "the royal mountain." to a village of tile-roofed dwellings that nestles at its base.

The village Monreal, with 350 inhabitants, is declining in human population as its young men and women move to Pamplona, a dozen miles away, or elsewhere in search of industrial jobs. And the mountain Monreal-home of a variety of eagles, falcons, kites, hawks, and vultures-is losing its raptorial birds. With its sheer, high cliffs reaching toward the summit, Monreal has long been a haven for these raptors. Indeed, northern Spain is believed to retain the highest concentration of these birds in Europe. (A biologist who drove 2,600 miles over the roads of northwestern Spain, for some ninety-six daylight hours one recent spring, counted 1,200 birds of prey of eighteen species. That amounts to one raptor for every two miles.) But the birds are declining in numbers all over this area.

That is the reason why the dead horse, a dray animal from Pamplona, has been brought by truck to Monreal's lower slope, rather than having been burned or, more conveniently, buried in the Pamplona city dump.

The carcass lies in a three-acre plot, within view of the mountain's summit. The plot is surrounded by pasture and fields and enclosed by chest-high wire fence, which is buried several feet into the earth. This fencing frustrates dogs, foxes, and other terrestrial carrion eaters. Animal bones litter the ground. Downwind of the chestnut horse are several other relatively whole remains; the sweet, nauseating smell of death is strong.

This is a comedero de buitres, a vulture restaurant. It is one of four already operating in the province of Navarre, and it represents a new tactic in efforts to conserve threatened raptorial birds. It was conceived by Dr. Francisco S. Irigoven, a lifelong resident of Monreal, who is a veterinarian and an expert on water-borne disease and sanitary waste disposal methods. Nature is his passion in life, and colleagues say he is a skilled naturalist and outdoorsman. Some years ago Irigoven noticed that several carrion-eating birds, particularly the huge griffon vultures (Gvps fulvus), were becoming relatively scarce. The griffon is Na-

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varre's commonest vulture; in Spanish it is called *buitre común*, or "common vulture."

Griffon vultures are widely distributed around the Mediterranean, and their range extends east to India. They were intensely admired, and feared, by biblical peoples, several of which worshiped them as sacred birds. Their name comes from the Greek, grypos, which means "hook-nosed."

On the ground, the griffon's most striking field mark is its long, whitish, gooselike neck, with a feather ruff at its base. The long neck is an adaptation that allows the bird to reach deep into a carcass for meat. The face and neck are essentially bare and featherless for antiseptic reasons: bacteria grow less well on bare, exposed skin than they do on damp skin hidden by blood-soaked feathers. Like the digestive system of all vultures, the griffon's will kill even virulent pathogenic bacteria.

Griffons are clumsy on the ground, and may need to take off into the wind, like airplanes, to become airborne. Once aloft, however, their huge wings carry them thousands of feet into the sky on updrafts, and they can glide for hours, seemingly without effort.

Griffons nest on high cliff ledges. Many of the birds that naturalist Irigoyen had enjoyed watching in the fields had their aeries on the cliffs near the summit

A griffon vulture and a magpie scavenge the remains of a carcass at a feeding station in northern Spain.



of Monreal. But recently, there were fewer of them to be seen and fewer, too, of the smaller, less common vultures and other carrion eaters.

Irigoyen tried to find out why the vultures were declining. Development was one reason: more people doing more things in the fields where the birds scavenge and on the crags where they roost and nest. Vultures are chary of humans and cannot tolerate their presence when breeding.

Gunners, too, contribute to the vultures' problem. In much of Europe, especially in the south, vultures and other nongame species continue to be shot by trophy hunters and other "sportsmen."

Pesticides may also play a destructive role for the vulture in Spain, where DDT is not yet banned, although scientific proof of this is lacking. But most important, Irigoyen felt, the birds were slowly starving. There were not enough dead animals for them to eat.

Navarre's carrion eaters had long depended on human bountifulness in the form of dead horses, cattle, and other farm animals, which often were dragged out to the fields where the birds could find them. Now, tractors are replacing horses on Navarrese farms. At the same time, the shift from cattle and dairy farming to grain crops is no help to vultures.

Animals that die, on farms or in cities, more and more are disposed of by so-called sanitary methods. They are burned or buried under earth and lime, not left out for the vultures. To Irigoven, these methods are both wasteful and dangerous. He believes that bacteria from a carcass moldering slowly in the ground are much more likely to reach the water table, through seepage, than are bacteria from a carcass on the earth's surface, which is quickly eaten by birds. Putting the carcasses in dumps, moreover, creates another hazard: they are dug up and eaten by dogs and foxes, which can carry contagion to other domestic beasts and even to humans.

Using his professional expertise in veterinary medicine, bacteriology, and sanitation, together with the knowledge gained from watching the birds in the field, Irigoyen articulated a social theory that could justify attempts to conserve the vultures. The traditional relationship between Spaniards and their vultures, he said, had been a two-way street that provided food for the birds and also

safe disposal of carrion for humans.

Here, then, was both reason and method for saving the vultures: Find available dead animals and feed them, in a naturally sanitary way, to the birds. Thus was conceived the vulture restaurant.

The organizational effort needed to realize the vulture restaurant owes much to a friend of Irigo-



A CAMOYAN, INCAFO

yen's, Juan Iribarren, who is president of a small conservation group, the Navarrese Society for Nature Conservation. Iribarren, an electrical engineer, works for the city of Pamplona. He appears to have convinced his superiors that it would be safer—and also cheaper—to cart animal carcasses twelve miles to Monreal than it would

be to bury or burn them close by.

This method for disposing of

This method for disposing of animal remains is equivalent to the human funerary practices of the Zoroastrians. Because Zoroastrians believe that burning or burying the dead will defile the sacred elements, they place the bodies of their dead on "towers of silence," where they are eaten by

On updrafts of warm air, a griffon vulture soars over the Pyrenean foothills.





Although capable of catching prev such as rodents, the black kite also relies heavily on scavenged meat for sustenance.

pondicherry vultures (Sarcogyps calvus),

Encouragement and backing were sought and received from the World Wildlife Fund. Land for the prototype "restaurant" was donated by a local landowner. The first carcass. a horse, was deposited in the restaurant in July, 1970, and the vultures quickly found it.

A one-story, stone and stucco observation building, with peephole windows, was built on the site. It was from here that the repast at the chestnut horse was

being witnessed.

Because vultures are extremely wary, an observer hoping to see them must enter before sunrise. The griffons, however, are not the day's first diners for they rise and soar on updrafts of warm air only after the sun's rays have warmed the land surface. Thus, magpies, which are wing beaters rather than soarers, are first to table.

With the sun up, the magpies retire to be replaced by a sitting of several jet black carrion crows (Corvus corone). They first explore the rotted body cavity of a longdead cow, but are soon taking turns feeding on the nag's eyes.

The carrion crow was the first Navarrese bird to suffer a population decline. While they are usually among the first scavengers to find a fresh carcass, they seem to eat only the eyes. If this is true, Irigoyen speculates, they would be threatened by any shortage of dead animals. Other ornithologists, however, challenge this concept because carrion crows, despite their name, are known to feed on many other things.

The next guest is an Egyptian vulture (Neophron percopperus), a soluring bird of noteworthy grace. It enters the scene slowly, another gourmand come to the feast. Its face, a masklike shield of bare yellow skin, has a primitive appearance. The yellow coloration continues forward into the beak,

which is about four inches long; its hook tip is black. On the back of its head, the bird has a collection of fine, egretlike plumes, which ruffle in the breeze. The body is whitish, about the size of a rooster.

This small vulture supplements its diet of carrion with excrement, including that of humans, in search of which it may venture into towns.

Its first choice of the morning is the aged beef; it works its way carefully through the galleries and passageways formed by the dried flesh and bones, stopping to pluck up a bite here, twist off a morsel there, picking things clean as it goes.

Then it moves to the horse, scaring off some returning magpies. The vulture mounts the head, samples nostril and lip, and then sinks its beak forcefully into the eye socket. Given its beak length and the apparent depth of its thrust, one cannot be certain whether the tidbits brought forth are vitreous humor, muscle, or nerve sheath—or underlying gray matter.

Having eaten, the vulture leaves. A kite—a raptor that takes both live prey and carrion—follows, but there are no other vultures. The griffons, which the restaurant was set up especially to serve, fail to come on this day, perhaps because there is very little wind upon which they might rise after dining.

Later, toward noon, a trip by Land Rover with Irigoyen up a rough, steep lumbering road that winds toward Monreal's summit reveals several of the griffons sailing majestically, high above the peak. On a niche in one high cliff, we see four young vultures-an encouraging number and a hopeful sign, Irigoven remarks. He estimates Monreal's griffon colony, as of 1974, at fifteen to thirty pairs and thinks they are recovering their lost numbers, while Navarre's other carrion eaters are at least holding their own.

The Monreal vulture restaurant nourishes not only this colony: in bad times, especially in winter, it attracts griffons from elsewhere in the province. On many days, Irigoyen says, seventy to eighty griffons are present, and on one day more

than three hundred were counted, which is greater than half the number believed to remain in Navarre.

It is too soon to quantify the effects of supplemental feeding on the carrion-eating birds of Navarre. Besides the four restaurants now operating, two others are planned. These, Irigoyen says, should be enough for the entire province of 4,045 square miles. Other restaurants, he says, ought to be opened in adjacent provinces. In southern France, there already is one in the Pyrenees National Park.

The World Wildlife Fund and other conservation groups are watching the vulture restaurant experiment with cautious interest. While they traditionally offer warm support to programs that tide threatened birds over particularly lean times, there is less enthusiasm for supporting projects that appear endless as well as expensive. The vulture restauranteurs might reply that this traditional model of assistance is appropriate only to birds that heretofore have been wholly independent of man. This is not the case with the vultures, which long have interacted with humans.

The cost, Iribarren and Irigoyen say, is low: about \$2,000 to open each restaurant, exclusive of the cost of the land, and about \$250 a year to run it.

The apparent early success of the Monreal vulture restaurant, and others like it, well may encourage similar ventures elsewhere, especially for birds whose "wild" ways have previously included some dependence on man. Conceivably this can be accomplished with little sacrifice of their remaining independence.

That the birds served also are of service to man can only add weight to the argument for their preservation. Says conservationist lribarren: "The vulture restaurant solves a double problem. It maintains populations of carrion-eating raptors and eliminates the bodies of domestic animals in the way that is most logical, most natural, and validated by the experience of thousands of years!"



The Waning of the West by Stan Steiner

photographs by Bank Langmore A new range war rumbles in the West. But this time the white ranchers, like the Indians they once displaced, are on the defense. Bulldozers for strip mines are ripping open the hills, destroying the grazing land. Overnight, sleepy ranch towns are becoming tawdry cities. And the cowboy is losing.



Bell Ranch; Bell Ranch, New Mexico



On the lonely and quiet two-lane ranch road that wanders peacefully along the Rosebud Creek, about ten miles from the Northern Cheyenne Reservation, there is a monument to the death of a myth. It is a weathered plaque on a small pile of rocks that proclaims that here, by this roadside, the Seventh Cavalry of General Custer rested for two nights before dying on the Little Bighorn.

Even today some think the road leads to doom.

Along the Rosebud Creek, where the ranches of the old homesteads nestled under great, grandfatherly trees on what had been Indian land, the fields are now green with summer wheatgrass and alfalfa. The country is beautiful. It is Big Sky country, wide and silent as the Montana prairie always has been. Some of the stones in these valleys are 65 million years old or older.

In the sagebrush foothills there are quail and coyotes. The ponderosa pines hide the shy mule deer and the sly bobcat. On the wilder open roads of Wyoming the herds of pronghorn are bolder. There they prance across the highways, halting the passing autos; but here they are camouflaged by the stillness of the hills—and wise fears.

One hundred years ago a pioneer Montana cowboy in the lands of the Northern Cheyenne, Edgar Beecher Bronson, wrote of this country as "a veritable aboriginal paradise." In his *Reminiscences of a Ranchman*, he described "the plains alive with buffalo and antelope, the mountains full of deer, elk, mountain sheep, and bear, the streams swarming with fish, and everywhere a thick carpet of juicy buffalo grass that kept their [Indian] ponies fat as seals."

Then the ranchers came onto the Indian lands. And then cattle displaced the buffalo. And then the strip miners came onto the ranchers' lands. And bulldozers displaced the cattle.

"And now the grass is gone," said one rancher. "It's being made into electricity."

On the Rosebud Creek, within sight of the Custer monument, a new range war began, but this time the white ranchers would be the Indians. It seemed quiet.
There was no shooting. And yet there was stirring in the
winds. The antelope sniffed it and smelled the
bulldozers coming.

In the company town of Colstrip, upwind a few miles, the strip mining had begun. There was talk of as many as seven generating plants being built in the sleepy town—population 266. One official of the Western Electric Company told the newspapers this might become the largest power project in the world, taking 10 million kilowatts of useful energy from the earth and wasting much more. If these huge plants were built, they might poison the sky with more ashes and acids, chemicals and pollutants, than in all of Los Angeles, New York, London, and Moscow together.

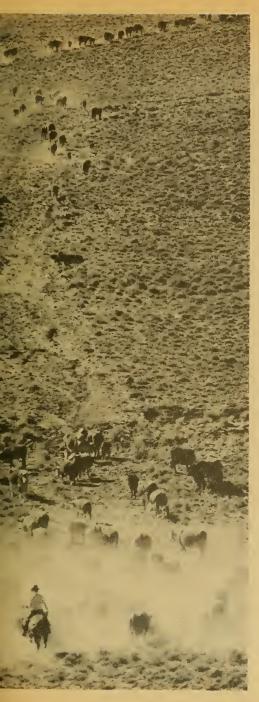
Some said a city of 25,000 would be built. And some said it would be more—or less. It did not matter, for the rural way of life was doomed no matter how many, or few, mobile homes and cheeseburger stands crowded the pasture of the antelope and steer.

The romance of a boomtown was a nightmare, declared a report of the Federation of Rocky Mountain States. In a typical resource city, modeled on towns such as Colstrip, it was found that crime increased 400 percent, psychiatric breakdowns went up tenfold, suicides zoomed, and divorces increased—more than 50 percent of the marriages fell apart in the social chaos created by a lack of housing where motel rooms rent on eight-hour shifts. There were often no schools for children, and the poor rural townships could not afford to build them. Lack of such simple necessities as sewers turned once-clear mountain streams into toxic cesspools. Living conditions were so bad that the job turnover was 150 percent. There was little entertainment other than bars and whores, and alcoholism became so commonplace that the local jails were often used by wives as protection from beatings by their drunken husbands.

Of course, clean air and wide open spaces were gone,



MC Ranch; Adel, Oregon



the report said, and the "effects on wildlife have been nearly disastrous."

On the road into the town of Colstrip there was a modest sign: Help Keep Our Town Clean. Beyond the sign, the huge smokestack of the power plant bellowed grayish smoke into the blue sky. Surrounding the plant, what little grass there was, was dying.

"The grass will die. And when it does, so will my ranch," one rancher said.

"Ranchers will vanish," said another, "like the Indians. We are the new vanishing race." He smiled.

One of the ranchers, a tall man of some dignity, his face hardened by the winds, his skin painted by the sun, was named Wallace McRae. He was one of the new white Indians.

"My grandfathers were early settlers," he said, "coming to Montana before the turn of the century, shortly after the Battle of the Little Bighorn where Custer met his demise while attempting to rid the West of the Red Menace." In those days, "Custer was an implement of the policy of the United States government that dictated that the Indian, his buffalo, and his way of life was an impediment to progress. The Indian, being an obstacle to economic development, had to be eliminated or overcome."

Wallace McRae now stood where the Indians had. "I have become, for all practical purposes, an Indian," he said. "Like the Indian, I am standing in the way of progress because I live and work above part of the world's largest known reserves of fossil fuel. But I resist," he added.

Four generations of the McRae family have farmed the stones and watered them with their sweat when there was no rain. The bones of his ancestors were like stones in this land. He thought of this land as an Indian might, with respect and humility. And so it was being taken from him, as it was taken from the Indian.

Love of the land is not a clear, legal title, they said.

Now the land he stood on was not his. They said he "owned" the top of the soil and that was all. The earth beneath his own feet, so rich with coal, was "owned" by the government. On most of the old homestead land, the government "owned" the mineral rights.

If you sink into the mud, I guess you could be arrested for trespassing, they said.

Most of our public, or federal, lands are in the western states. Some 725 million acres—more than one-third of the entire nation—it is a vast region, as large as western Europe. These lands are run by government decree. In some of the states, Wyoming, for example, 71 percent of the land is controlled by a single, small agency of the Department of the Interior, the Bureau of Land Management. None of the land barons of the old West ever dreamed of possessing the land and power of these minor bureaucrats.

On the ranchers' land the government could lease the coal from under their feet, their porches, their bedrooms, if they wished. And they did.

Wallace McRae had seen it happen to his neighbors. One rancher's grasslands were selected as the site for a gigantic, 1,200-megawatt electric plant. He was not even told. He did not know his ranch was involved until he read about it in the newspaper.

The ranch of a neighboring family was sited for strip mining, but neither the coal company nor the government bothered to show the rancher their environmental impact statements. So he had no idea what would happen to his ranch or his family.

Many pastures were drilled for coal samples without asking the ranchers, under the assumption they could not prevent the drilling. And no prospecting permits were issued by the government.

When the academic experts of the Westinghouse Corporation did a study of the impact of strip mines and power plants on ranch life along the Rosebud, they surveyed everyone and everything in sight. "But they did not include a single rancher," said McRae.



Quien Sabe Ranch; Channing, Texas



6666 Ranch; Guthrie, Texas





After talking to perhaps 300 ranchers and ranch hands on the prairies of Montana and Wyoming, the Northern Great Plains Resource Program summed up their feelings this way: The majority of ranchers in the Rosebud and Powder River regions "would really like to see the coal people go away forever. They are traditionalists. They and their hired hands think the whole business is wrong. They are committed to maintaining the land and its integrity."

It was strange, they thought, because "in the past, ranchers tended to identify strongly with big business." Why had they become disenchanted?

"Some ranchers," the report went on, say the coal and energy companies are "unfair, untrustworthy and inconsiderate . . . deceitful and interested solely in making money. They send surveyors without first asking for appropriate permission." In this way they start a scare rumor to frighten ranchers into selling their land. And then, after getting a big head start in construction work on someone's land, before getting formal permission from the rancher or the government, they argue that the heavy commitment they have made should be approved.

The ranchers are dumbfounded by the morality of the power companies. They feel greatly handicapped for, "valuing credibility, trust, and honesty," they have "difficulty in dealing with corporate tactics." They "make the mistake of treating corporations as people."

These old-fashioned ranchers feel powerless:
"Ranchers are keenly aware of the tremendous power—both financial and political—held by the industrialists, who are in a position to stifle a productive ranching operation virtually overnight. Knowing this, very few persons believe that coal development and ranching can go on side by side."

In despair, some of the older ranchers sold out and hoped for the best. On the Quarter Circle U Ranch in Birney, Montana, the aging owner, Burton Brewster, talked wonderingly of one-quarter of a million dollars

Bell Ranch; Bell Ranch, New Mexico



he was offered in coal royalties for the thirty-six acres it took "to run one cow." Brewster was wistfully hopeful: "This quarter of a million dollars this one cow would generate would go a long ways... with the money I am sure my grandchildren can make a better ranch."

In Roundup, Montana, Boyd Charter, another oldtime rancher, replied angrily: "Can you actually look your neighbors in the eye? I am as old as you are. I have engaged in the business of running cattle my entire lifetime. As I see it, it would be an utter impossibility to run cattle side by side with strip mines and power plants. Are you willing to put a plaque up on your ranch saying you sanctioned the strip mining of the place? I'd be goddamned if I'd want such a plaque up on my ranch. God help us."

The feeling of coming doom became a front-page headline in the *Denver Post:* "Western States View Dismal Future." It eulogized the passing of the spirit of

the old West: "Longtime residents, fearing an end to a beloved life-style, say, 'Now we know how the Indian must have felt."

It echoed across the western prairies and mountains. . .

Up in Montana and down in Texas the sorrows were the same. The ranchers even used the same words to curse those politicians who were sacrificing "rural life for urban death," as one old-timer put it.

On the ranch of Bob Green in Albany, Texas, the old cattleman cursed the damming of a prairie river to supply water for an industrial city fifty miles away. "The river bottom was our winter pasture and the horses stayed fat. Now we have to feed them all winter and they don't do as well. It sounds like *Bury My Heart at Wounded Knee*. Poor old Indians, they probably felt the same way when we ran them off."

If these ranchers had the feeling that they were being treated like Indians, it may have been because they were. To many corporate and government energy experts, ranching seemed a kind of dreamy nostalgia. Those old homesteads on the prairies, like rural life itself, were secondary to the manifest destiny of urban energy demands. Some of the ranchers had begun to call themselves "white wards of Washington." They accused the Bureau of Land Management of being the "Bureau of White Indian Affairs."

It may have confused these white ranchers that the government mistook them for the red Indians they had belittled, insulted, and laughed at for most of their lives. And yet it should not have. The second-class citizenship of ranchers had been recommended as government policy, in the energy crisis, by the official 1970 report of the Joint Congressional Commission on Public Land Review. Entitled *One Third of the Nation's Land*, this policy report on western land use stated, in categorical italics:

Mineral exploration and development should have

preference over some, or all other, uses on much of our public lands.

The energy of the grasses was to be secondary to the energy of the coal deposits. The urbanized commissioners acknowledged that in days past "grazing has always been part of the western scene, and livestock ranching has had a major role in public land use. . . ." But that idyllic memory of America's past was unprofitable nostalgia. The old West had to be displaced by the new West, in which "development of a productive mineral deposit is the highest economic use of the land." And so the primary use of the western prairies and forests was no longer ranching, but mining.

So then, let what Fortune magazine called the New Age of Coal begin. There was a "Persian Gulf of coal" beneath these ranchers' pastures; it would be worth billions of dollars when converted into electricity for the cities.

The sea of coal would flood the prairies. It was a tidal wave, sweeping away ecological laws that for generations had protected the fragile land. The restrictions upon leasing of public land coal deposits should be "removed or modified" at once, the impatient commissioners said, for the "public interest requires that individuals be encouraged—not merely permitted—to look for minerals on public lands." And so, "We urge dispatch," they said.

Not merely the ranchers, but the environment itself—the grasslands and pastures, mountains and forests—were secondary to the primary use of the land for mining and power development. The commissioners said: "We believe that the environment must be given consideration, but regulations must not be arbitrarily applied if the national importance of the mineral is properly weighed." Land is to be "restored or rehabilitated after a determination of feasibility based on careful balancing of economic costs." That is, the costs in cash, not in grass. And besides, "Rehabilitation





does not necessarily mean restoration." So much for the rhetoric of reclamation.

In setting down this statement of policy, the commissioners were merely saying what everybody had been doing for years. After all, the Joint Congressional Commission had been convened in 1964, years before the energy crisis became a popular exorcism; it reflected the opinions of some of the most influential and decisive men in Washington, such leaders as Senators Henry Jackson and Clinton Anderson, Congressmen Morris Udall and Wayne Aspinall, and one lone representative of industry, whom the New York Times referred to as "Laurance Rockefeller, conservationist."

These men had simply suggested that our national priority and business practice become government policy. In their straightforward, forthright efforts, they were immediately attacked by both ranchers and environmentalists. "A blueprint for corporate takeover of 724.4 million acres of land which now belongs to the people of the United States," was how Angus McDonald, research director of the National Farmers Union, characterized the commissioners' work. It was "a bankruptcy sale of the nation's western lands and resources." It was "the biggest land grab proposal in history." It was the death knell for homesteaders; from now on you had to be a giant corporation to do a little homesteading.

Logically, the Joint Congressional Commission had recommended that the Homestead Act be repealed. The small farm and ranch had gone the way of the horse and buggy.

These ranch homesteads and family farms had become "an agrarian myth," as the National Water Commission said. Every year there were fewer and fewer old-fashioned farmers. In the summer of 1973 the Department of Agriculture estimated that barely 5 percent of the population lived on farms. There were fewer than three million farms left in the whole country. And two-thirds of these were not even subsistence



6666 Ranch; Guthrie, Texas





Bell Ranch; Bell Ranch, New Mexico

farms, being so small and so poor that they sold less than \$2,500 worth of produce yearly, earning the farmers but a few hundred dollars.

Scoffing at the poor farmers, one secretary of agriculture said with paternalistic disdain: "They are pretty much the salt of the earth [but] contribute little to feeding the urban population." They could not feed themselves.

As the farmers vanished, so did the farmland. The interstate highways, suburban developers, power plants, and strip mines had begun gobbling up the cropland at the rate of 750.000 acres each year. By the year 2000, it was reported, 60 million acres of choice farmland would disappear and so would about 300 million acres of grazing land.

The severe shrinkage of our rural lands, towns, and people was becoming a national disaster, warned Leon Keyserling, the former chairman of the President's Council of Economic Advisors in 1965. Rural life was being sacrificed to urban needs and that was economically unsound and inhuman. "It is not enough to save half the people of a ship by casting the other half into the sea," Keyserling said.

Something had to be done. Nothing was. In his compassionate rhetoric, Lyndon Baines Johnson, himself a rancher, twice urged Congress "to restore the balance between rural and urban life." The romance of the down-on-the-farm imagery had been an obligatory theme of presidents before and after Johnson, but his appeals were an expression of more personal *angst*; he proposed no programs of significance, however, and nothing was done, then or since.

In a factual declaration of what was, and is, national policy, the undersecretary of agriculture, Charles S. Murphy, one of President Johnson's close advisers on farm problems, set things straight with unusual bluntness: "I think it is a mistake to go too far in trying to keep people on the farm when it doesn't make sense economically," he said. "If we would just recognize the



Bell Ranch; Bell Ranch, New Mexico





fact we are going to have fewer people making a living farming. . . . We do not have any moral obligations to patches of land," said the undersecretary.

That was that. Here was an honest, no-nonsense statement of priorities. In our society, where most of the people and the power reside in the cities, the memory of rural life is quaint and enchanting, but it does not have the national importance in reality that it seems to have in advertisements for deodorants and cereals, "paper moons" and John Wayne movies. The Marlboro Man has become a myth of the media.

And yet, the less important ranching was, the more romantically it was portrayed. The less countryside was left, the more city people dreamed of leaving for the countryside. Like the vanishing Red Man, the vanishing white rancher became more and more popular as a romantic ideal only when he began to fade in real life.

And so it has always been. The cowboy became a folk hero, as Frank Dobie once remarked, when he became a "cowboy without cows," no longer having even the "smell of cows." Until that time, he was thought of as dumb, unwashed, uncivilized, ill-mannered, and illiterate to boot. For there was little romance in love of cows. Not until the open range was fenced and the cattle drives had ended and the cowboy was becoming a memory of the past did he become the hero of the Buffalo Bill Wild West Shows, to be enshrined within the Cowboy Hall of Fame.

So it was with the modern rancher. He became a folk hero on television, after his way of life on the range was doomed—by television.

In the "good old days" the rancher was both idealized and deprecated. He was glorified and ignored. He was no "better than an Indian," and in some ways worse. He had "half-Indian ways," wrote Constance Rourke in *The Roots of American Culture*.

He was too backward and too radical. "You can hardly find a group of ranch men or miners who will not have on their tongues' ends the labor slang of Denis





Kearney, the infidel ribaldry of Robert Ingersoll, the socialistic theories of Karl Marx," cried the Reverend Josiah Strong, the leader of the Congressional Home Missionary Society, a kind of Billy Graham of the 1880s. Strong sent his missionaries to save these "white Injuns," much as they did the "inferior tribes" of "aborigines"—for the ranchers were just as "beastly."

In *Trails Plowed Under*, the Montana cowboy-artist Charlie Russell parodied this view of the Wild West and the wilder westerner in a delicious dialogue:

"Ma," says she, "do cowboys eat grass?"

"No, dear," says the old lady, "they're part human." It was an old Indian joke, retold by whites. Just the names were changed, for in the pioneer West cowboy was a dirty word, as bad as "savage." The cowboys preferred to be known as buckeroos, a gringoizing of the Spanish vaqueros. "Cowboy" was an insult; it was "one name for many crimes," wrote a Texas chronicler in the 1850s; it meant "outlawry" or "banditti" or "uncivilized."

Among the Mexican vaqueros of the Southwest the feeling was different. When a man was a fine horseman or unusually skilled with cattle, it would be said of him, Se crio entre los Indios pues—"He grew up among the Indians."

"Contrary to a lot of false statements, a man took pride in calling himself *Indio*," wrote Arnold R. Rojas in his beautiful book *The Vaquero*. "They would say of a man who showed much Indian blood, *Ese no le debe ni los buenos dias a la Espagnoles*—"That one doesn't owe even a 'good day' to the Spaniards."

So much of the Indian heritage of the western rancher and cowboy has been forgotten. Or it has been expurgated and mocked by the ironies of history.

In the myths of the West, farmers and ranchers were romanticized for so long in the idolatry of political oratory, in novels, and in films that they, too, came to believe they were the salt of the earth. In reality, they have always been second-class citizens, the white



ZX Ranch; Paisley, Oregon



Padlock Ranch; Crow Agency, Montana





Injuns. The needs of the rural west have been secondary to the demands of the railroads, the land speculators, and the mine owners.

Sometimes ridiculed, sometimes humored, most often the ranchers and farmers have been ignored by the Congress until they howled and cursed in the "farm rebellions" that became as common on the prairies as the old "Indian uprisings." Even then, the eastern Establishment tended to regard rural anger as something archaic and exotic.

In the heyday of the farm rebellions, when the people were still largely rural, it was this way. In 1872 one of the pioneer Masters of the Grange, Dudley W. Adams, admonished the prairie farmers and ranchers to forget the pastoral myth about themselves: "Politicians laud in stentorian tones the 'honest yeomanry,' the 'sinews of the land,' and deluge us with equally fulsome and nauseating stuff. . . We have heard enough of this professional blarney," he raged. "We must do something to dispel old prejudices. . . . That the farmer is a mere animal is an ancient, but abominable, heresy."

And yet, even when the land was deeply agrarian, rural people had little more influence than now. "Look at our State and National governments," said Adams, "to whom [do] we entrust this great responsibility . . . a lawyer, doctor, preacher, student, merchant or, in fact, almost anybody but a farmer.

"My brother tillers of the soil," he exhorted, "what we want in agriculture is a new Declaration of Independence. Let us proclaim that our farms need not be 'the abodes of overworked slaves.'"

Slaves of whom? It was Wall Street that had mortgaged the lives of "widows and orphaned children," declared one Grange broadside in 1873. The money interests were the enemy.

This oratory echoed a popular ballad of the early Grangers:

Brothers of the plow, the power is with you.





Oppression stalks around; monopolies abound. Their great hands already clutch the tiller of the ground.

Awake! then Awake! the great world must be fed. And Heaven gives the power to the hand that holds the bread.

Yet the Grangers, Populists, Greenbackers, and Farm Unionists were never more than dissident groups in politics. They did not come to much. They did not last. They did not succeed in halting the urbanization of the countryside. Since Shays's Rebellion in 1786-87, uprisings of farmers had been losing battles, unable to stem the concentration of power in the cities.

So were they still.

On the prairie of Laramie, Wyoming, ranchers protested the building of high-power electric lines across their land without their consent. The Bureau of Reclamation had simply condemned the land. Once, ten years before, they had fought and lost that battle. Now they were adamant, but they lost again.

Ranchers near Gillette had gotten together to protest the railroad being built to haul forty-eight trains of strip-mined coal through some of their best pastures every day. They vowed no one would sell out until a majority agreed. "We don't want to sell anything," said Earl Scott. But he was reconciled to the idea that "somebody is going to get hurt by this thing." And they were. They couldn't halt the railroad.

In the burning deserts of New Mexico, Rita Hill, a seventy-one-year-old widow sought to protect her cattle ranch from a highway interchange—"It doesn't provide access to anything but my pasture"—by building a



Main Street; Ingomar, Montana



shack in its path and facing the bulldozers in her bonnet, until "they drag me off by force." They did, and she was arrested.

The Rosebud, Tongue and Yellowstone sugar beet growers, the Buffalo Rapids Irrigation Project, the Custer Rod and Gun Club, and Trout Unlimited filed a petition in court requesting that the Federal Power Commission assume jurisdiction over water use by the Colstrip power projects. They did not win.

In the valley of Sarpy Creek, ranchers asked for a court injunction to halt a Westmoreland Coal Company's strip mine. They lost.

Everywhere in the West it was much the same. If the desecration of the land was halted it was usually because a federal bureaucracy or corporate energy company had decided that the project would not be economically profitable. Not because of the land or the people.

And when the old-fashioned ranchers reluctantly joined hands with their ecology-minded sons and daughters in the city, they were faced with ugly bumper stickers that said: "Let the Bastards Freeze in the Dark."

"In Al Capp's play. Li'l Abner, it was decided by the federal government that Dogpatch was the most unnecessary community in the USA," said rancher Wallace McRae. "There is a Dogpatch stigma attached to rural areas that says that since there are few people in the ranching areas, they are relatively unimportant."

No one listens to rural people. And it is at their own peril that they do not. "You can't raise beef in our urban centers," McRae said. "And I think you better not preclude our ability to raise beef and wheat and corn and pine trees in rural areas."

In these words there is the sound of sorrow. There is a sense of loss, as inevitable as the evening's twilight, that mutes his anger.

"I have begun to discover that after nearly one hundred years of honest endeavor, my family's effort





Jersey Lilly Bar and Cafe; Ingomar, Montana





does not amount to much," McRae said. Still he fought for his ancestral land. "I think if these plants are completed, all of us in Montana are going to look some day at a scarred landscape under a filthy sky, cut by dry river beds, populated by a callous, socially chaotic population, and we will say what fools we were for not stopping this exploitation when we had the chance. A French philosopher, Raynal, once said: 'There is an infinity of political errors, which being once adopted, become principles.'"

The philosophy of Wallace McRae was also the philosophy of old "Sockless" Jerry Simpson, a Populist congressman from Medicine Lodge, Kansas, who long ago said, "The man who owns the earth, owns the people." He was remembered, too, for saying, "Man must have access to land or be a slave." In the valley of the Rosebud, ranchers knew that without knowing.

"In the language of my neighbors, the Cheyenne Indians, the name for white man is the same as that for spider—veho," McRae said. "As I see the webs of the high voltage lines, the webs of railroads and strip mines, the poisons we exude from our activities, the rivers sucked dry of their.life-giving juices, I am reminded of the wisdom of the Indian, exhibited by his prophetic name for us. Truly, we exhibit all the characteristics of a veho.

"Perhaps I feel this way because my ranch and my way of life are threatened. Perhaps I am selfish in wanting the world to pass me by," he said.

In America's memories the ideal of democracy has been the town meeting in a small farm town. Once it was believed that the nature of our land and our democratic beliefs were wedded. And that democracy itself had arisen from our closeness to the earth. As Frederick Jackson Turner, the historian of the western frontier, wrote, "American democracy is fundamentally the outcome of the experience of the American (white) people in dealing with the West." Democracy was not, he said, an urban idea.



Quien Sabe Ranch; Channing, Texas

Those who dreamed of a humane and individual democracy grew fewer every year. It was not easy to have faith in a Jeffersonian ideal of rural democracy when the country yearly became more darkly urbanized and desolate. One of the few men who kept that faith was Dr. Paul Taylor, former dean of the economics department at Berkeley, who in the late 1920s, wrote the first modern papers defending the small and

democratic family farm.

"Who owns the land is not something trivial to the nation," Taylor said. "It is central to our society, to our economy, and to our political system. Our New England ancestors were committed to a belief that widespread distribution of land ownership was necessary for the kind of society they wanted to create. This is what this country is all about."

Most people no longer knew anything about the land, the old man acknowledged, but "they will. They'll come to it. They are beginning to wake up. This issue isn't as remote from urban problems as some people think.

"Much of the population pressure and discontent that disturbs our cities [is because] we have fostered an agricultural system that has driven the modest family man off his farm. And we reap the social consequences in our cities." He continued that the land had to be cultivated by people who live on it, or the meaning of America would be lost.

The paradox was clear. If the energy hunger of the cities meant inflicting urban problems on the rural countryside, then the problems of the countryside would migrate to the cities. And urban problems and energy hunger would intensify. In a peculiar way, the solution was the problem.

For many ranchers and farmers it was too late. The feeling of despair that clouded the prairie and mountain states was expressed by J. Homer Jackson, a small-town banker who specialized in farm loans in Rifle, Colorado: "There never has been a time in the history of this nation when the economic survival of America's farm families has been more critical than it is today. We can't go on." Economically and politically, the rural people are facing extinction.

"Farmers and small-town businessmen have made this a strong nation," the banker said, "But when the wealth is concentrated in Wall Street, and the Populists aren't making any money, then this will break the nation."



Jackson had been born in a sod dugout on the prairies seventy years before and had seen many changes. But this seemed to be the end of the road for the descendants of the pioneers of the West. They knew it. "When they can't go any further, they sell out," he said. "Many of them move."

One by one the small farm and ranch towns have closed down, like country fairs on dirt roads. The Main Streets stand silent and empty. The old general store has been replaced by a new supermarket, the old town bank is an antique shop, and the old Bijou movie theater has been torn down and paved over for a parking lot.

Even the old depots are locked. Who needs them when so many people have left.

In the Feed Bag Cafe in the ranch town of Ashland, Montana, in the midst of the strip mines, a radio was whining a country-western lament, sung by a musical non sequitur known as The Fifth Dimension:

> They're tearin' down the street where I grew up Like pourin' brandy in a dixie cup They're pavin' concrete on part of me No trial for killin' a memory.

A cowhand looked up sourly from his cup of coffee. He squinted at the radio as if it were his mortal enemy. But he hunched over his coffee cup, not rising, his head bent, knowing that even if he got up and smashed the radio the words would still be there, in the air,

> Ashes to ashes dust to dust. It's the way the West was won.*



6666 Ranch; Guthrie, Texas



Thirty years ago, Stan Steiner set out from his native New York City and, after hitchhiking across the country, settled in the West. He now lives in Santa Fe, New Mexico. Describing the region as "the last refuge of Thomas Jefferson, Sitting Bull, Manuelito—and myself—" he is committed to preserving the land and the life-styles it offers, themes he has dealt with in numerous books. Among these are The New Indians; La Raza: The Mexican Americans; and The Way: Anthology of American Indian Literature. Steiner's latest book, The Sun Is Becoming Darker, from which this essay is taken, will be published next year by Harper and Row.





Bank Langmore has been interested in cowboys since he was a young boy, when his grandfather, who was one of Theodore Roosevelt's "Rough Riders," regaled him with stories of the West. Born in New York, he was raised in Cuba and, after World War II, moved to Texas, where he has lived since. To obtain the photographs that appear in this supplement, and which are part of a book, The Cowboy, to be published by Ridge Press in September, Langmore spent one year traveling from Mexico to Canada. Outfitted with his own saddle, bedroll, and cameras carried in specially fitted holsters, he covered about 20,000 miles of cow country, riding and working alongside the ranchers, and sometimes spending as long as twelve hours on horseback.

Announcements

A Contemporary African Arts Festival continues through July in Gallery 77 of The American Museum of Natural History. This exhibition, on loan from Chicago's Field Museum of Natural History, consists of more than 200 works in graphics, painting, sculpture, pottery, carved calabashes, resist-dyed textiles, counter-repoussé, leatherwork, architecture, and handloomed tapestries.

A traveling exhibition of the Smithsonian Institution. Egyptian Tapestries, is on display in the Akeley Gallery of the Museum. It features some 30 handwoven tapestries from the workshop of the late Dr. Ramses Wissa Wassef, as well as color slides and black-and-white photographs. The tapestries were created in Dr. Wassef's experimental workshop near the Giza pyramids. Dr. Wassef, an ar-

chitect, potter, weaver, and teacher, sought to revitalize disappearing crafts and techniques.

Trash Can Be Beautiful suggests ways to recycle everyday trash into toys or games for children. Leonard Todd, a Yale-trained architect who gave up designing new towns to pursue a writing career, has created a space station using take-out food containers and disposable coffee cup tops, and a castle made from tin cans and half-pint containers. These exhibits can be seen in the People Center and the Hall of Birds of the World, on the second floor of the Museum.

In the Hayden Plänetarium, **Between the Planets** continues through June 30. This show examines major planets and satellites of the solar system. Opening July 1, a

new show, "Universe Calling," will examine the Milky Way and question the possible existence of other life in outer space and time. Sky shows begin at 2:00 P.M. and 3:00 P.M. during the week with more frequent showings on weekends. Admission is \$1.75 for adults and \$1.00 for children.

The Museum Shop, completely renovated and expanded, carries a large selection of international merchandise, many handmade and one-of-a-kind. Items include jewelry and colorful artifacts from around the world, as well as books, posters, and wall hangings. A new discount structure has also been established. Members are now eligible for a 10 percent discount on both books and other merchandise. The shop is located on the first floor, off the 77th Street Foyer of the Museum.

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Gingerbread in Romania

by Jan Harold Brunvand

The cities are modern, the handicrafts commercial, but elaborate decorations on peasant homes attest to a flourishing folk tradition

As Romania's population surges, and more and more people leave the countryside for jobs in urban areas, there is a great press for housing. Consequently, the Romanian government is concentrating its official housing program on the production of large apartment blocks in or near the major cities. Usually covered in stucco, the color and texture of oatmeal, and rising a monotonous ten or twelve stories, row after row of these dismal buildings provide much-needed living space, but they are sorely lacking in beauty, comfort, and variety. Typically, the units are cramped, the interior finish shoddy, and mechanical devices operate erratically.

In contrast, houses in small villages and rural areas are attractive individual family homes, built by hand according to regional traditions of material, form, and décor. This is folk housing in the classic sense of the term—building that follows age-old patterns passed on by customary example. The colorful array of styles in which many of these peasant houses are decorated is a folk art that is flourishing in the midst of modernization and rapid industrial growth.

House decoration may not seem to be a genuine folk art, especially in tourist-conscious Romania, where so many folk products are the handwork of press agentry designed to lure the foreign traveler. Count Dracula is better known to Bucharest travel agents than to Transylvanian peasants, and there seem to be more brightly costumed natives playing violins in restautants than crossing the village greens. Yet by adding color and design to the inside and outside of his home, the contemporary Romanian peasant is continuing a tradition that can be traced back at least two centuries, and he employs some motifs that date from the time of his Dacian ancestorsthe original inhabitants of Romania who resisted the Romans.

Since the government strongly supports ethnographic research, museums, and the handicraft cooperatives that produce ceramics, textiles, wood carving, jewelry, and other exportable handmade products, the survival of certain aspects of Romanian folk art is no accident. House decoration, however, is neither salable nor subsidized. A distinctive form of folk expression, with both traditional and innovative elements, it is kept alive simply because people continue to practice it. In some Romanian villages virtually every house seems to be slathered with embossed and brightly painted stucco designs, adorned with intricate wood or metal ornaments on gables and roofs, and dripping with sawed fretwork and wood appliqué.

Some of this is simply the result of keeping up with the neighbors. As a resident in one such village explained it to me, "First one man decorates his house, then his neighbor does, and soon everyone wants his own house to be just as beautiful." While contemporary local fashions must account for some of these clusters of vivid dec-

oration, as well as for the repetition of certain styles of balconies, windows, or roof shapes in small areas, this villager's answer was too simple to explain the more widespread patterns. Clearly, there are also ethnic, regional, and period variations on a few limited themes that suggest a mature tradition of true folk art.

The roots of this housing tradition are ancient. A type of simple one-room structure, occasionally still used, has a prototype in the floor plan of Neolithic huts excavated in southern Transylvania. These were made of posts, wattle, and packed earth. Only slightly more elaborate two- and threeroom houses are common today in any Romanian village and, in fact, throughout much of the Balkans. These elemental house types are made of wattle, log, earth, or stone, depending upon the topography, available raw materials, and local traditions, and appear in distinct zones. Except for one small subzone in southwestern Romania, all of them are still built without chimneys; the fireplace or stove flue runs to a spark catcher in the attic, and the smoke simply escapes through the roofingsmoking, on the way up, the meat that is hung from the rafters.

For a craft that begins with such humble materials and is carried out by traditionally trained workers, the final results can be amaging indeed. The actual building of a peasant house is supervised by a village folk construction specialist, with labor often furnished by the members of the family who will live in it, all working at it whenever their regular jobs allow the time. It is taken for granted that the builder will secure some deco-



ration for the new house, the type and amount based on the owner's preference and finances.

Sun-dried adobe-mud mixed with manure and chopped strawis still one of the major building materials of Romanian houses, even now when the doors and windows are generally factory made and hauled from the city in horse carts. Stone, fired bricks, and cement blocks are other base materials for similar houses. The roughly finished adobe houses are plastered over with a thinner mud mixture, while the stone, brick, or block houses are coated evenly with cement or plaster, all three materials indifferently referred to as "stucco." While the surface is still damp and soft, designs and inscriptions are embossed, and the finished house is whitewashed or painted, with the embossing highlighted in contrasting colors. Other trim may be added on eaves, gables, roof, and porch.

In the mountain and forest regions of Romania, wood is favored for house construction, with builders using either shaped or round logs laid horizontally and closely notched together in saddle, V, or dovetail joints. In the past, finished log homes, like the peasant wood churches, were left unpainted, so time and weather have gradually taken their toll, leaving some of the oldest examples in shaky condition but still held together by their original pegs and notches. Some parts of the wooden houses and churches, such as pillars, beams, and railings, are decoratively carved. Particularly elaborate wood carving developed in the forested areas of northern Transylvania and western Oltenia. where wooden houses, churches, roof gates, farm tools, and domestic utensils are all richly ornamented.

Log or rough wood-frame houses in some regions are sided with nailed-on withes or laths; then these houses, too, are plastered over in the manner of the adobe and brick houses. Along the lower Danube River Valley, and especially in the Danube Delta, houses are frequently constructed of reeds tied to a wooden frame.



The roofs are also finished with reed bundles, and the gables are decorated with cut-out wooden horse head or rooster shapes at the top. In other regions roofs are of straw thatch, shingles, tiles, and in recent years, sheet metal.

House decoration, although part of the folk tradition, was undoubtedly influenced by the rich professional artwork found on princely dwellings and churches. The sophisticated stucco designs on the Fundeni Doamnei church and the palaces of Potlogi and Mogasoaia—all built by Prince Constantin Brincoveanu in the early eighteenth century—have their counterparts in the graceful patterns of flowers, vines, and animals found on Walachian peasant houses made of adobe and plaster.

More importantly, however, the traditional colors, patterns, and themes of house decoration can be found in other handicrafts as well. Colors and some designs used on ancient pottery and icons predominate in wall hangings inside homes, as well as in carvings or paintings outside. The basic floral and geometric designs of old weavings and ceramics reappear on house walls, while the horses, cocks, lions, and other creatures of house decoration are placed in similar conjunction on pieces of needlework.

Just as the typical Romanian regional costume is pure white with a few colorful highlights on the sash, vest, or headpiece, the oldest houses are white ones with simple painted borders. Still seen throughout the country, these houses are whitewashed all over, then outlined in dark red or blue around the edges of the walls, doors, and windows. Traditionally. women did this decorating, priding themselves on their skill in producing perfectly even outlines. An equally wenerable style—less commonly met with nowadays—was a whitewashed house decorated with unpainted embossed borders of geometric design comparable to the white-on-white embroidery found on older costumes.

Gradually diverging from these two rather restrained traditions was the use of embossed decoration painted white and set against a solid background of dark blue or rich yellow. Or the embossing itself was sometimes painted in contrasting colors against the traditional background of whitewash. The primary colors red, yellow, and blue (those of the Romanian flag) are often seen on these houses, as well as on glass icons. First used in the period between the two World Wars, and now well established in tradition, is a whole spectrum of colors, shades, tints, pastels, stenciling and marbelized effects. Modern tastes and fashions have encouraged bright, polychromatic treatments of façades, which stand out dramatically from the simpler modes of the past.

Interior house decoration in Romania, often even richer than that on the exterior, varies with the different regions and ethnic groups. Romanians of German extraction, for example, use a great deal of paint on their furniture. Interior decoration consists of carefully arranged carved furniture set against a background of tapestries and curtains, icons, and pieces of local ceramics arranged in tiers along all four walls, literally from floor to ceiling. Woven towels are draped over each hanging bowl, pitcher, or icon; plump embroidered pillows are piled high on the bed: In the special "clean room" of many peasant homes even the beams are hung thickly with ceramics or textiles, while groupings of carved wooden utensils and yet more pottery sit on the mantlepiece, windowsills, and tabletops.

Most Romanian traditional

house types include a porch and often a projecting balcony as well; both provide favorite places for rest, gossip, and handwork during clement weather. These, too, are decorated to enhance their role as a pleasant supplementary living area. Porch pillars are usually carved or painted or both. Railings, brackets for pillars and eaves, bargeboards, and other sawed wooden trim are produced by local craftsmen-workers other than those who build the house itself. Such "gingerbread" woodwork may simply be left to weather, resulting in a classic plain house with natural wood trim, or it, too, can be painted; the same is true of wood appliqué. As with the plaster decoration, brightly painted designs are now replacing the old weathered style of woodwork.

Extending the principle of outlining, window trim may consist of carving the unpainted wooden sills and frames or, as has become common on modern plastered or cement exteriors, highlighting with color the embossed designs placed around windows. Many householders even decorate some of the window glass itself with sheets of colored or metallized paper.

Gable and roof ornaments, very common in Romanian folk architecture, take a number of distinctive regional forms. In Dobrogea, one often sees fretwork and wood appliqué, in the form of fish, snakes, stars, and stylized plants, on the gable ends of houses. Other houses have tiny roof dormers (where smoke can escape) or towers above the porch balconies; these in turn are sometimes decorated with animal, bird, or geometric shapes.

Recent Romanian house decoration has freely adopted modern materials and themes. Decorative shapes are often cut from sheet metal. In regions where pottery is manufactured, rows of glazed ceramic decoration may be attached to exterior walls. Also popular lately is the house entirely covered with small, commercially glazed ceramic tiles. Arranged in geometric patterns similar to what was occasionally done in earlier times with painted wood shingles, these

Details from houses throughout the Romanian countryside. Despite the introduction of freeform designs, traditional geometric patterns, whether carved or painted, still predominate. The small, repeated shapes along the roofline, bottom right, are known as "larks" because they look like a row of perching birds.





patterns are similar to some geometric weaving patterns. Another popular treatment employs small mirrors set in a row or arranged in shapes and even inscriptions on the stucco walls of a house.

For the past fifty years or so, Romanians have painted murals, often of idealized landscapes, on their houses. While they seem to suggest the famous exterior religious frescoes of the sixteenth-century Moldavian monasteries, these "kitschy" treatments of secular subjects are more like old-fashioned calendar art. These are put on by itinerant painters, who work from magazine clippings or sample paintings they carry with them. A peasant may choose a Dutch windmill, a castle, a grouping of animals and hunters in the forest, or perhaps a seascape for his house. Some people even order three or more such scenes placed in a row along the façade of a house.

The more interesting of these wall paintings are not attempts to copy a picture—usually unsuccessfully—with photographic accuracy; rather, they have the abstract quality of naïve art. I saw paintings of this sort showing rocket ships and steamboats, others that pictured foreign animals (perhaps seen in a zoo), and one landscape that had a childlike rendering of carefully symmetrical mountains and trees looming over a peaceful settlement in the foreground.

All of the more realistic and colorful treatments are relatively modern in Romanian folk art. But at the root of many of the decorative additions to peasant houses is an age-old system of symbolism, with some symbols persisting from ancient times. Rosettes and spirals, found also in many archeological remains—pottery, jewelry, cos-

tumes—represent the sun and evoke its power. The "rising sun" form of the solar symbol also occurs. Snakes and stylized serpentine designs are reminiscent of the protective house serpent of popular superstition and decorate many a bowl or tapestry from long ago, as well as some modern houses.

The sacred tree, or Tree of Life, motif occurs in different forms in Romanian folk art. On glass icons it can be the Edenic Tree of Knowledge, but more typically in the Romanian peasant conception it is painted as the Mystic Wine Press, shown as a grapevine springing from the wound in Christ's side, arching over his head, and having its fruit squeezed by the Savior directly into a chalice. The Tree of Life now recurs as part of house decoration in the form of a stylized, narrow symmetrical plant, often arranged in groups of three or with three branches.

Elements of the human bodyusually only a face or a hand-appear in Romanian folk art as symbols of the controlling mind and the moving force behind the homemade artifacts. These are found carved on gates, fences, well sweeps, wayside crosses, and utensils in or near houses and churches, and occasionally on house walls themselves. Horses and birds employed widely in the decorative tradition seem to symbolize strength and spirit, respectively; while most lions, stags, and dragons, judging from their poses, can be traced to heraldic designs once seen in the coats of arms of the nobility. The occasional dog, rabbit, squirrel, or other animal sometimes pictured on houses is probably purely decorative.

Today, inscriptions on houses are usually restricted to names, initials, monograms, and dates, but in the past longer sayings, such as, "Till money I get from my father-in-law/ My roof it, alas! must be covered with straw," were also found. Christian crosses are commonly found, particularly in the German-settled parts of Transylvania, but seldom does one see the hammer and sickle or any other recent political design. Above all,

throughout all Romanian folk arts and crafts, geometric patterns lines, crosses, notches, fans, swirls, circles, stars, cubes, and pyramids—continue to flourish.

While the iconography of house decorations presents some solvable riddles, their esthetic appeal to their owners and builders is more difficult to explain. It is hard to understand why these peasants have given up the classic simplicity of the older styles, such as the minimally adorned, traditional whitewashed house so attractive to my eye, for the frenzy of décor found in the newer modes. Doubtless, just as regional folk costumes and ceramics have become more colorful and elaborate, so also have changing artistic tastes influenced house decorations. But this explanation is hard to reconcile with the psychedelic tic-tac-toe design l saw on one house or the huge, ragged, freehand polka dots on another or the vivid orange-pinkgreen-silver paint job on many others. These all seemed to clash with, rather than complement, the colorful but more tasteful older house décor, folk costumes, and handicrafts of their regions.

Perhaps there is some expression here of other factors. Faced with limited life-styles, a scanty choice of consumer goods, and little opportunity to travel, Romanians may turn to their personal environments as a source of stimulation and variety. In the same way that traditional dances, feasts, and rituals-associated with both festivals and personal celebrations such as weddings-provide relief from everyday drudgery, the strikingly colorful house decorations help counteract the often dull visual world of starkly functional postwar streets and buildings.

Whatever the complex motivations behind these folk creations, it is obvious that shaping, carving, embossing, coloring, and outlining have created many pleasing house designs. Moreover, the increasing popularity and sophistication of such techniques testify to the viability of a true folk art form despite Romania's rapid industrialization and development of commercial handicrafts.

Traditionally, houses were trimmed with a subdued border design, above, but in recent times, bright, polychromatic decorations have become the fashion.

The Snake That Lost Its Habitat

Mark S. Newton and Russell Smith

When the western forests retreated, the California mountain king snake became stranded in marginal refuges on the bottoms of a few canyons

Tuna Canyon. In the growing August twilight, our vision was beginning to play tricks on us as we searched for fossil deposits. A gentle movement at our feet startled us-a California mountain king snake! For the next few moments, we were filled with the excitement that comes from having encountered something rare and precious. It seemed a miraculous event to find this lovely snake in its extremely narrow stream bed habitat, only a few hundred feet from the noisy Pacific Coast Highway.

A living contemporary of the fossil coniferous trees we were looking for, the California mountain king snake (Lampropeltis zonata) is a survivor of climatic changes that banished the redwoods from the Los Angeles area several thousand years ago. With a troubled sigh for the insecurity of its present habitat, we watched our snake disappear into a tangle of blackberry vines.

In his book The Reptiles of North America, the late Raymond L. Ditmars called the California mountain king snake "the most beautiful snake in the United States." On a collecting trip to the San Bernardino Mountains in search of the species, Ditmars, with great perseverance, was stripping the loose bark from fallen pine trees when he suddenly uncovered one of the prized snakes,

which fell to the ground, looking "like a handsome necklace in the forest debris." In another work Ditmars portrays the species as "broadly ringed with the brightest vermilion, the red separated by rings of cream-yellow, then margined by lustrous black."

Subsequent writers have used the number of these sequences of red rings bordered by black onescalled triads-as the basis for recognizing some seven different subspecies, or geographical races, of the California mountain king snake. The subspecies found in the Santa Monica Mountains is L. zonata pulchra (pulchra means "beautiful"). Although the striking physical characteristics of the California mountain king snake have been well described, little has been published about the paleogeographic circumstances of its occurrence in the Santa Monica Mountains.

Throughout its range, from Klickitat County in southern Washington to the San Pedro Már-



tir Range of northern Baja California, the California mountain king snake is usually found in forest dominated by the western yellow pine (*Pinus ponderosa*). In the southern parts of its range, the distribution of yellow pine forest becomes more patchy and discontinuous and so does the distribution of the mountain king snake. The strongholds of its range in southern California are at elevations between 5,000 and 7,000 feet in the San Gabriel, San Bernardino, San



Jacinto, and Peninsular Mountains, including the Palomar and Cuyamaca areas. In some places, as in the great canyons of the San Gabriel and Santa Ana rivers, the mountain king snake is able to survive at elevations as low as 2,000 feet. Its occurrence throughout southern California's ubiquitous dry brush forest, or chaparral, is entirely within corridors of remnant moist riparian environment.

In the Santa Monica Mountains, which split the Los Angeles area into an L. A. Basin and a San Fernando Valley, the mountain king snakes are entirely disjunct—separated from other populations of the same species by miles of unfavorable topography and habitat. Furthermore, the forest-loving snake seems out of context in the Santa Monicas, where the only conifers growing today are those that have been planted by humans. How can we account for this apparent anomaly?

The easiest and most interesting way to approach this problem is to assume, along with the late Phillip Munz and other California botanists, that the distribution of conferous forests in southern California had a different pattern in the past. During the latest of the

Pleistocene ice ages, about 10,000 years ago, climates were cooler and moister, more like northern California's Humboldt and Mendocino counties today. Yellow pine, Douglas fir, and redwood forests were able to spread into areas now covered with chapafral.

The mountain king snake came along as a member of these forests' biotic communities. When warming and drying of the climate caused the forests requiring heavy moisture to disappear, the mountain king snake was able to persist only in shaded canyons. Proximity to the cool waters of the Pacific Ocean helped, and in the Santa Monica Mountains today, the mountain king snake-along with some interesting floral elements such as the big-leaf maple (Acer macrophyllum)-is an "ice age relict," a survivor from former climates.

Thus the mountain king snake is at home in the Santa Monicas, having arrived there as a member of an ecosystem that was cooler and moister than the present one. Its persistence in restricted, isolated habitats is due to a combination of climatic and geologic circumstances. Post-Pleistocene trends toward warmer temperatures and an accompanying aridity have been marked by a lowering of the winter season's rainfall from a total of more than thirty inches in the late Pleistocene epoch to only about fifteen inches today. Higher temperatures also promote evaporation and lower the retention rate of rainfall in the soil. Consequently, except for the riparian woodland and broad sclerophyll vegetation in the bottoms of

With six other subspecies, the Sierra mountain form of the California mountain king snake shares a preference for moist woodland habitat. protected canyons, chaparral has replaced forest. And here we must consider geologic factors.

Like other parts of California's Transverse Ranges, the Santa Monica Mountains lie in a basically east-west direction. Mountain-building pressures, currently quite active, are directed from the south, as frequent local earthquakes show. The Santa Monica Mountains are actively being pushed up into a fifty-mile-long anticlinal arch; concomitant downcutting by streams is taking place very rapidly. Where a stream cuts down through resistant rock, a deep, narrow gorge results. Such gorges are abundant in the Santa Monicas, particularly on the southern, ocean-facing flank, where hard Miocene volcanic breccia and the mighty Chico Formation of late Cretaceous age outcrop.

The Chico Formation is massive and resistant; stream downcutting has left narrow defiles bordered by towering cliffs of boulder and cobble conglomerate. The bottoms of such deep canyons intersect the water table and receive groundwater seepage. Because of their narrowness they are constantly shaded and remain cool and moist throughout the year. Lush groves of California bay laurel occupy narrow, lateral terraces within the canyon, while the sharply incised stream banks are overgrown with blackberry vines, wild rose, and poison oak, brilliant red at the end of the dry season. More sheltered places within the canyon are apt to have stands of sycamore and coast live oak. Sunnier parts of the stream bed hold tangles of arroyo willow, and the steep slopes are impenetrably overgrown with California walnut and the greenbarked shrub Ceanothus spinosus.

The mountain king snake's world is a microcosm. What sets the dynamic boundaries of this microcosm and why is the species strictly confined within it? The environment sets limits to the growth of any population. Evidently, the environment above the canyon bottoms contains limiting factors too stringent for the maintenance of mountain king snake populations. Lack of water is not one of

DISTRIBUTION OF THE CALIFORNIA MOUNTAIN KING SNAKE IN THE LOS ANGELES AREA



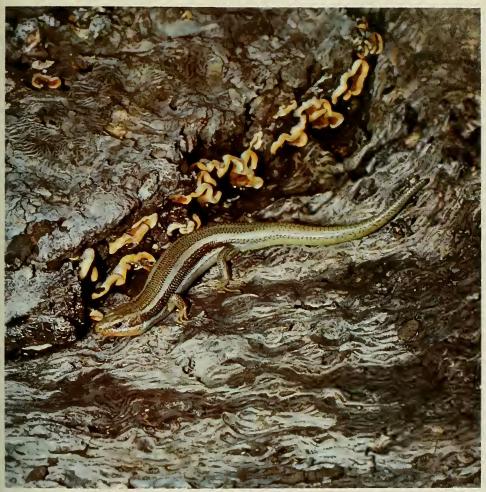
these limiting factors, for like many other snakes, the mountain king is able to go for long periods without drinking. Nor does this snake depend upon certain food species that can live only in the canyon bottoms. The California mountain king snake is a second-and higher-order carnivore whose chief prey consists of species of lizards that are also abundant in the chaparral and other nearby environments.

High rates of predation and competition for food with other animals may be a factor in keeping the mountain king snake out of the chaparral zone. This snake is a secretive creature of the shade; its distinctive coloration is a definite liability in an open or patchy environment like the chaparral, where it can be more easily spotted by predators. In the chaparral there is also the problem of competition for food with larger, faster, and stronger species of snakes, such as the California two-lined whip snake and the chaparral patchnosed snake, which feed on the same lizards as the mountain king snake. That the California mountain king snake can survive in the brushlands in the absence of competition is demonstrated by the Todos Santos subspecies (Lampropeltis zonata herrerae), a most interesting relict on a small island off the Pacific Coast of Baja California. Significantly, the Todos Santos form, living in a more exposed habitat, has lost the red members

of its triads—possibly through natural selection exerted by avian predators.

Reptilian competitors in the form of other snake species can and do stray into the habitat of the California mountain king snake, but they cannot fully exploit it. These larger reptiles need great patches of sunlight to maintain optimum activity temperatures; the shady canyon bottoms are too cool for them. But the California mountain king snake, like its eastern relatives the milk snakes, can operate effectively at lower temperatures. In the Santa Monica Mountains it has what amounts to an ecological specialty-foraging through the gloom for semitorpid lizards. We think-although herpetologists have debated this issue-that the red bands play an adaptive role in this specialty. This can be illustrated by making a circular pinwheel, marking it with pie-shaped segments, and coloring the segments sequentially-white, black, red, black, and white. If the wheel is spun even in moderately bright light, the moving segments appear to blend into an indistinct gray. A hapless lizard thus may not notice a foraging snake until it is within striking range.

In the manner of all king snakes, the mountain king snake subdues its prey by constriction. Prey species are mostly lizards, but small snakes, mammals, and nestling birds may be taken. By the feel of a prominent bulge in its middle,



DALE THOMPSON

we judged that our Tuna Canyon specimen had recently eaten a scaly western fence lizard (Sceloporus occidentalis), the most abundant lizard of the canyon bottoms. The diet may also include the westernskink, western side-blotched lizard, Los Angeles ring-necked snake, and juvenile members of larger species, such as Hammond's garter snake and the California striped whip snake, or racer.

Just as our Tuna Canyon snake was discovered at sundown, so it seems that in southern California the species may tend to be crepuscular, or partly nocturnal, in its summer habits. We have several records of its having been encountered on roads as late as 9:00 or 10:00 P.M.

Rare and secretive as it is, we believe the mountain king snake manages, in April or May, to follow a trail of musk laid down by another of the opposite sex and to mate. In July the female lays a clutch of about five eggs in decomposing wood or moist soil. If undisturbed, the eggs will hatch in approximately sixty-three days. The mounSearching for insects along the decaying trunk of an upturned tree, a western skink may itself become the hunted—skinks are a favored food item of the California mountain king snake.

tain king snake and its eggs probably have their natural enemies; coyotes, skunks, and raccoons would be likely predators. If it strays into open, grassy habitat, the mountain king might well become an item in the diet of the much more powerful California (common) king snake (Lampropeltis getulus californiae). But, especially in the Santa Monica Mountains, man is the worst predator, taking a fearsome toll of the species.

For the Santa Monica Mountains synopsize a familiar modern tragedy: a fragile wild system surrounded and isolated by encroaching human culture. Threats to the survival of the mountain king snake in the Santa Monica Mountains all stem from the proximity of too many people with too much mobility and too little understanding of nature. For example, we can expect increased killing of the species in the erroneous belief that it is a venomous coral snake. (In coral snakes the sequence of rings is reversed: "Red on yellow, hurt a fellow." And coral snakes do not even occur in California.) There will be increased destruction of habitat through trampling. Many of the canyons have roads, and the mountain king snake's habitat happens to be very attractive to highly mobile, freedom-hungry Los Angeles youth.

A worse threat to the mountain king snake stems from its own great beauty. In the snake-collecting set this is the top prize, conferring highest status upon the finder. Professional collectors, however, are more sinister in their efficiency. One recent price list we have seen offers Lampropeltis zonata at \$125 per snake. The state of California has new laws designed to curb the traffic in native wildlife, but these are weak. The snake's official status of "depleted," with a bag limit of one per person does not provide the mountain king snake with much effective protection.

But the ultimate danger to the mountain king snake is destruction of its habitat by massive land alteration and development. Los Angeles County's Sanitation Department has the Sisyphean task of disposing of what may be the world's greatest production of trash. This is presently accomplished by the filling-in of Santa Monica Mountain canyons nearly to the top with a new kind of geologic deposit, the "sanitary landfill," composed of old tires, lawn clippings, rusty tricycles, and so on. Mission Canyon is currently being filled, and unspoiled Sullivan Canyon is tabbed next. Big developers, already well established in the Santa Monicas, have plans for the "clustering" of condominium-type dwellings in some of the broader canyons. In lower Santa Ynez Canyon, where twelve years ago we found a mountain king snake, the bottom habitat has been entirely displaced by concrete drainage and a high-speed road. Proposed roads, freeways, and flood control projects are alterations that would selectively obliterate mountain king snake habitat.

Much vital land will be lost. Land for public use is often obtained from developers by a deal in which the uplands are sold to the public as park land while the canyons are retained and developed. Moreover, the upland parks must have access roads to accommodate many visitors, and roads often have to be built through canyon habitat. Where the watershed is in private hands, wastes and pollution drain into the canyons from various developments. Mountain heights are often spacious, but canyons are narrow, hence very sensitive to disruption. We have only to consider the numbers of people and human interests in and around the Santa Monica Mountains to be able to predict that the future looks grim; extinction may be the fate of the California mountain king snake and other Ice Age refugees in the canyons.

Having captured a western skink, a California mountain king snake shifts its hold to swallow its prey.





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Go Mango!

Struggling against the odds of prejudice, this superlative fruit is gaining a foothold in North America

While most of us were paying no attention, the mango came to America. The most luscious of tropical fruits is no longer an exotic oddity. Thanks to the growing numbers of Spanish-speaking people in our cities, even supermarkets now sell several varieties grown in Florida, the Caribbean, and Mexico.

But like many a recent immigrant, the mango is misunderstood. Well-meaning people, mango demi-vierges, have, it is true, dared to nibble at one or two of the fruits of the noble Mangifera indica. And they have certainly admired the red blush on the green peel of a jumbo Florida mango. But then disappointment set in, for one or more standard reasons. Now it happens that there is a good explanation for each of these antimango prejudices. And as a perfervid mangophile, I want to take this opportunity to refute all the slanderous charges, one by one. Please note that, in every



BERYL GOLDBERG

by Raymond Sokolov

case, ignorance of the basic facts of mango botany and mangiculture has contributed to the spread of an unfounded antipathy to a superlative fruit. Moral: learn botany and eat better.

Bias 1: Mangoes are tough. Unripe mangoes are tough. Most mangoes are picked before they have completely ripened and are sold, still hard, in stores. They are more practical to transport this way. But unlike some more familiar fruits that suffer from this kind of early harvest, mangoes, some experts say, actually improve in taste when they are picked early, and they are less susceptible to spoilage than tree-ripened fruits. In India, the world's mango capital and the probable original source of the plant, there is ongoing debate on this point. But an informal experiment conducted with mangoes in an American kitchen last summer proved that the fruit will ripen to a delectable softness, palpable through the peel, in a sunny, open place under northern skies. You just have to wait. Or you can leap right in and cook the green fruit (see recipe below). As the fourteenth-century Turkoman poet Amir Khusru said, couching his thoughts in Persian verse: "The mango is the pride of the garden, the choicest fruit of Hindustan; other fruit we are content to eat when ripe, but the mango is good in all stages of growth." The important thing is to realize that there are different ways of dealing with the green and the ripe mango.

Bias 2: Mangoes are fibrous and taste of turpentine. Only the best varieties of mangoes are wholly palatable. There is immense differentiation within the species because cultivation has occurred for something like 4,000 years, according to the usual estimate. And most of that cultivation was achieved with seedlings, each



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of which had its own genetic personality, so to speak. As a result, in India there are now more than 1.000 varieties on record. Furthermore, substandard, seedling-borne fruits tend to grow fiber in the pulp. Fortunately, it is possible to graft buds from high-quality trees onto seedling stock and thus perpetuate gastronomically successful variants through vegetative reproduction. This is the standard method everywhere today, but some growing areas, especially in Latin America, do produce commercial fruit from inferior trees. Still, fibrous mangoes are a rarity in North American markets.

"Turpentine" mangoes are more common. Their unpleasant taste is an unhappy reminder that botanical classification is more than an abstruse system based purely on structure, for Mangifera is a genus of the Anacardiaceae, a family that includes Pistacia terebinthus, the tree that gave turpentine its name. Rhus vernix, the varnish, or poison-dogwood, plant is another Anacardiaceae. Some mangoes exhibit this resinous family curse to excess and cannot be eaten with pleasure. Other mangoes start out with a whiff of varnish and lose it when they ripen fully. Most mangoes that you are likely to buy do not taste noticeably of turpentine, especially if they are chilled. But all mango leaves do ooze a turpentinelike volatile liquid when they are crushed.

Bias 3: Mangoes give you a rash. Linnaeus has the last laugh again. The most famous members of the Anacardiaceae are poison ivy, poison oak, and poison sumac. Their cousin mango can produce a similar allergic affliction, although normally with less severity. Moreover, far fewer people seem to be troubled by mangoes than by their irritating relatives.

Bias 4: The seeds are hard to sprout. After you finish eating a mango, you are left with a large seed or pit with juicy hairs trailing from it. A burgeoning cult of amateur gardeners has sprung up whose mania it is to make these pits turn into household plants. This is a bit of a trick to bring off but far from impossible. An acquaintance of mine has a tree in Rockland County, New York, that bloomed last spring for the first time, right on schedule, in its tenth year. I know of two younger

mango trees that grew in Brooklyn without benefit of green thumb. Know-how is all you need.

There are at least two schools of thought about the best way to make a mango seed germinate, as a recent controversy on the garden page of the Sunday New York Times demonstrated. One faction advocates planting the whole pit. The other plumps for cutting away the husk and potting the inner kernel alone. Both methods are used by commercial growers. With the husk left on, the seed has a slightly greater chance of sprouting. With the husk off, the process moves faster. Failure is not so much a matter of method but of dead seeds or seeds from unripe fruit. The seeds are relatively shortlived, which was the major reason that mango trees did not spread beyond Asia until the age of rapid transportation.

If you decide to sprout a whole seed, wash and brush away all the pulp that clings to the outer fibers of the husk. Then soak the seed in water for five days. Plant it in loose loam with the plumule, or stem end, up, under a thin layer of soil. Germination may occur anywhere from three weeks to four months

afterward. More inquisitive home horticulturists will want to pursue the kernel method, to cut away the husk and see that the nut inside resembles nothing so much as a giant cashew. (The cashew, Anacardium occidentale, is, of course, the tree that gave the Anacardiaceae their name.) The kernel, having been suitably admired, goes directly

into soil, plumule up. With either method, germination leads to a fragile, frost-threatened sprout topped by translucent, reddish leaves. These turn dark green, leathery, wavy at the edge, and tapered at the end. They range from six to sixteen inches in length and look like spear points. Every few weeks after germination, in a spurt of growth known as a "flush," the plant emits more leaves. In tropical and subtropical climates, mango trees eventually flush their way to immense size. The largest mango on record, at Chandigarh, India, attained a maximum girth of 28 feet and a spread of 200 feet. Heights of 90

feet are not uncommon. These

behemoth trees are landmarks.

looming over the land. "The mango tree was so big," says the heroine of Jean Rhys's novel, Voyage in the Dark, remembering he Caribbean childhood, "that all the garden was in its shadow and the ground under it always looked

dark and damp."

Some of these evergreen giants send out as many as 2,000 fivepetaled flowers from each panicle, or cluster of blooms. Yellow or red with purple anthers, the flowers typically have five stamens, but only one bears pollen. If frost kills them, the tree can produce a second generation in the same season. Indeed, four flowerings have been observed in one season in Cuba. Healthy blossoms give way to a drupaceous fruit, with flat sides and rinds that range through a spectrum of yellows, greens, and reds. In size, they may run as small as plums or as large as some melons. Several thousand of the smaller fruits can grow on a single mature tree.

This bounty has made the mango the staff of life for poor Indians. Entire villages subsist on little else but mangoes during the summer. Even the seeds are consumed—dried and roasted, ground into flour, and cooked as gruel. No wonder that the Hindi word for mango, am, also means "the masses" or "the populace." (Our word mango derives from the Ta-

mil man-kay.)

tang to many dishes.

More affluent Indians revel in the fruit as connoisseurs; they dote on it, vie over secret sources of spectacular specimens; they savor raw mangoes, mango curries, mango chutneys, mango custards. The pulp, dried in the sun with spice, is another delicacy. Powdered mango, amchoor, adds a tart

But to mango-obsessed Indians, the mango is more than a celestial food. It is a central part of Indian tradition. It recalls the time of the Mogul emperors, when the great Akbar planted 100,000 trees. It is enshrined in the Ramayana epic, which mentions forests of mangoes. The five petals of the flower symbolize the five arrows of Kama Deva, the Indian Cupid. The blossoms beautify the worship of Sarasvati, goddess of wisdom and the fine arts. A mango grove was presented to Buddha. The mango's epithet in Sanskrit is Kalpa-Vriksha, the wish-granting tree.



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As a result, there is mango ice cream in New York's Chinatown. And mango jelly in our Hispanic markets, to be served with cream cheese. But best of all there are fresh mangoes as early as March. Fresh mangoes to devour in a rich and fragrant gulp. No cooking necessary, just a tantalizing wait for ripening. But if you don't want to wait, here is a way to convert green mangoes into a smooth, glossy spread that will keep for several weeks.

Green Mango Jam

Green mangoes are mangoes of any color that are still firm or, to put it another way, slightly underripe. This is usually the condition of mangoes in American markets.

This preserve, which is prepared all over the tropics during the mango season, can be used like any other jam. Or, if you cook it only half as long as directed below, it will make an excellent filling to bake in a raw pie crust.

- 1. Peel several green mangoes. Simmer them for 30 minutes in a covered, nonaluminum saucepan filled with enough water to come halfway up the mangoes.
- Cut the pulp of the mangoes away from the pits and put it through a food mill. Use a cup to measure, or a scale to weigh, the resulting purée. Then transfer it to a clean, nonaluminum saucepan.
- Stir in half as much sugar as you have pulp. In other words, add one-half cup sugar for every cup of pulp or, say, four ounces of sugar for every eight ounces of pulp.
- 4. Slowly bring to a simmer. Continue to simmer, uncovered, for 15 to 20 minutes, until jam thickens. Test by dripping a little on a plate to see if it sets.

Raymond Sokolov is a free-lance writer and food columnist.

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An Awful Warning

MINAMATA, by W. Eugene Smith and Aileen M. Smith. Holt, Rinehart and Winston, \$19.95 (\$10.00 paper); 208 pp., illus.

Minamata Bay lies on the west coast of the southern Japanese island of Kyushu and faces the Shiranui Sea. Along the shores of the bay are scattered a number of villages and homes where fishermen and their families live. The town of Minamata extends easterly from the same bay. Life in the town has been dominated for many years by the Chisso Corporation, a petrochemical and plastic materials company, whose factory also lies within a short distance of Minamata Bay; close enough, in fact, to be connected to it by a drainage channel, through which industrial wastes from the Chisso factory are emptied into the bay waters.

As long ago as 1950, local people noticed some unusual occurrences in these bay waters.



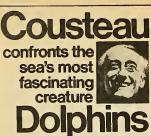
Dead fish—and not merely culls from fishing boats—were seen floating on the surface. Shellfish were dying in unusual numbers, and even some seaweed appeared to be dying. By 1952 the situation became noticeably worse: whole stretches of dead fish could be seen floating throughout the bay and

out into the Shiranui Sea. Cuttlefish swam around in such a weakened condition that children could catch them with their bare hands. By the following year cats in the Minamata area began to be stricken with a bizarre malady. The local people at first called it "the dancing disease" or "the cats' disease." The cats would stagger about, salivating; suddenly, they would be struck by convulsions and would whirl about in violent circles. These gyrations usually ended in collapse and death. Within five years after the first outbreak, virtually all of the cats in the area had disappeared.





For centuries, the people of Minamata, a small fishing and farming village on the island of Kyushu, have been dependent upon the fish and shellfish taken from the surrounding sea. Above, the waste pipe of the town's petrochemical company discharges industrial poisons directly into Minamata Bay.



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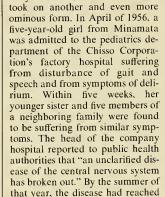
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epidemic proportions. Most of the

affected people were from Min-

amata and surrounding villages. Their illness became known in Ja-

pan as the "Minamata disease."

Investigations by local health authorities disclosed about thirty such cases. Many of the victims turned out to have been ill for several years; their symptoms had been previously ascribed to alcoholism, viral inflammation of the brain, and a variety of other maladies. Actually, when a research group of the Kumamoto University Medical School was set up to investigate the case of the outbreak, it was found to be due to a type of heavy-metal poisoning caused by eating fish and shellfish from Minamata Bay. Since the only evident source of heavy-metal pollution in the bay was the Chisso factory effluent-which included manganese, thalium, arsenic, mercury, selenium, copper and leadthe general cause-and-effect relationship was readily indicated to the medical people concerned.





But, strangely, nothing appears to have been done to take prompt prophylactic measures to protect the local population from further exposure to the cause of the disease. The Chisso factory did not stop the discharge of its heavy-metal effluent into the bay until 1958, when it diverted it into the Minamata River, which ran directly into the Shiranui Sea. (The effectiveness of a subsequent treatment of the effluent before the point of discharge is a matter of sharp dispute.)

By late 1956 there were fifty-two known victims of the Minamata disease. Their symptoms, which began with sensory disturbances of various kinds, including speech disturbances, and with weakness and tremors, increased and eventually developed into deformity, general paralysis, convulsions, and frequently, death. Of the original

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fifty-two victims, twenty-one died within one year of the onset of the disease. A high concentration of mercury was found in the internal organs of these people. By 1960, the causal element involved was clearly identified as methyl mercury poisoning. The identification was made, it seems, despite a singular lack of cooperation from the Chisso Corporation. For example, when, in 1959, a company physician fed effluent emerging from

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the plant to a cat, and the cat developed symptoms of the Minamata disease, the company forbade him further access to samples of the effluent and removed him from the experiments he was making. The company, like many others, had taken the position that the mercury content of its effluent was inorganic and inert. But research had already indicated that bacteria in the disposal area were capable of converting inorganic mercury into water-soluble organic mercury, which then entered shellfish and fish life and thus entered the human food chain.

The Minamata outbreak is an awful warning of the consequences of headlong and unregulated industrial pollution. The entrance of methyl mercury into the aquatic food chain from industrial wastes is, as we now know, occurring on a worldwide scale. The dimensions of this threat in our country alone can be surmised by the fact that of the more than six million pounds of mercury used industrially each year, up to half that amount is lost in the environment, including rivers and lakes. Only recently, according to a report in the London Sunday Times, the director of the French National Institute for Health and Medical Research warned, on the basis of organic mercury and other pollution in the Mediterranean, that a Tuscan or Provencal fisherman of twenty



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who currently may eat, from his catch, four or five pounds of fish a week may well become chronically ill by the time he is thirty. The major source of this gathering disaster is industrial effluent.

In Minamata the human effects of the tragedy have been recorded in photographs and text by the well-known photographer W. Eugene Smith, with the cooperation of his wife, Aileen M. Smith. In a harrowing series of photographs, Smith shows the attempts of the victims of Minamata-nearly eight hundred have so far been positively identified and ten thousand people may eventually be found to have been affected-to cope with the inexorably debilitating and excruciatingly painful disease. And his photographs and text show the attempts of the victims to organize themselves to obtain compensation from the Chisso Corporation, attempts that remind one of the ordeal of the deformed victims of thalidomide poisoning and their families to obtain some semblance of compensation for their ruination by this other chemical form of Russian roulette. (Some financial compensation was eventually obtained by some members of both classes of victims, although it has been grossly inadequate, of course, in terms of the suffering caused.) In the course of his most persistent photographic documentation of the Minamata disaster, Smith himself became a victim of corporate resistance to acceptance of its full responsibility. During a demonstration of victims outside company headquarters, Smith was so badly beaten by strong-arm men protecting company premises that he was permanently injured and almost lost his sight. His book is an angry and passionate work. It has, perhaps-particularly in a rather disconnected text that makes the sequence of events in Minamata rather hard to reconstruct-some of the defects of a Life photo-essay, but it is a work that deserves honor for the professional steadfastness, the humanity and the deep personal respect for the victims of Minamata that lie behind the images he has created.

Thomas Whiteside is a staff writer for The New Yorker magazine and the author of Defoliation (Ballantine Books).



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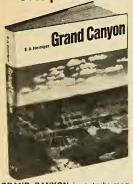
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Astronomy at the Frontier

Some vital astronomical observations can only be made by instruments above earth's atmosphere

Above the earth's atmosphere there is now available, for the first time, an unrestricted window for observation of all radiation wavelengths, from the shortest wavelength X-rays and ultraviolet rays through the visible to the infrared and the extremely long radio waves. The terrestrial atmosphere, which shields us from so much of the spectrum of impinging cosmic energy-and information-glows weakly itself, so that even though we go to the remotest and darkest regions of the globe, it is never as dark there as it is above the earth's atmosphere. The darker the background sky, the more readily can fainter and more distant objects be detected. The earth's atmosphere also spreads out rays of light so that even with the largest ground-based optical telescopes we get only blurry images of cosmic events. Above the atmosphere, however, we can achieve perfectly steady pictures, right down to the exceedingly small resolution limits of whatever telescope aperture we use.

For all these reasons, space is

the natural environment from which to observe the astrophysical events that manifest the most fundamental and powerful laws of the universe in which we live. Just what are these laws and what can we expect to learn about them from a space observatory?

Some scientists feel that most of the laws of physics are already known, and that what goes on in the far reaches of space and time are merely differently scaled versions of terrestrial physics. Other scientists feel that the deepest laws of physics are yet to be discovered-perhaps in these same far reaches of space and time. Whichever proves to be true, it is undeniable that on the scale of galaxies-agglomerations of billions of suns, as in our own Milky Waythere exist forces, organizations, and time scales that so dwarf our terrestrial experiences that their workings are almost incomprehensible. For example, in the interior of some galaxies, energies are encountered that are so enormous that the whole unbelievably massive core is rupturing outward under the force of some titanic explosion. What causes such incredible forces? Perhaps the only way to find out is to look directly into the nuclei of these exploding and ejecting galaxies. For this we

will need the resolution possible only with large-aperture space telescopes.

How are galaxies born? Certainly one of the most profound unanswered questions is how the matter was created out of which our planet, our galaxy, and we ourselves are made. There are many ways of tackling this difficult and basic problem. Some of them involve observing distant galaxies that are very young and very faint. We need the dark skies of outer space against which to observe these objects. We need accessibility to the unlimited wavelengths of extraterrestrial observations. With them, the riddle of planetary and stellar formation may also be illuminated by space observations of young stars, galactic spiral arms, and interstellar dust and gas clouds.

How important is such knowledge? I believe its importance is beyond measure. Humans have always sought to know the nature of their environment-as protection against potential dangers, for purposes of survival, or merely to satisfy a basic and insatiable curiosity. In fact, man probably could not begin to understand himself or have any sense of purpose without some understanding of the environment and its potentialities.





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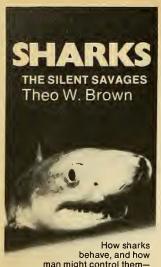
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What is required, as always, is pure knowledge.

Some space astronomy has, of course, been going on. Sounding rockets, balloons, interplanetary probes, and satellite space laboratories have been flown. Most of these activities have taken place under the aegis of the National Aeronautics and Space Administration. Many administrators, engineers, and scientists-including some professional astronomershave worked together, relying basically on available military rockets, boosters, and space hardware to carry out this preliminary exploration into space.

But the time has now come. I believe, when this effort should be planned from a purely scientific point of view. The need is for a National Space Observatory in order to establish a permanent scientific staff, ranging from leading astronomers to young Ph.D.'s just gaining research experience. In that way really long-range, continuing projects can be organized and carried through. In a National Space Observatory the problems could be conceived, the most effective observational approaches designed, and the observational instruments needed to solve these problems could be built and operated. This is the modus operandi that has made the National Radio and Optical Observatories so effective, and this is what is needed for space astronomy. Certainly such an institute of professional astronomers would not replace NASA but would establish a block of independent career astronomers who would work with NASA and provide the leadership in planning astronomical goals.

I believe the time has also come to shift emphasis slightly by making increased use of military hardware for space astronomy, developing space hardware directly for scientific exploration, and allocating increased federal budgetary support for development of space astronomy. After all, if we are to survive over a long term, the most serious dangers we need to defend ourselves against are unexpected events that menace our society on a large scale. Experience has shown that, in general, the things that save us in the face of serious emergencies, both natural and man-made, are new and sophisticated scientific techniques of information gathering, communication, analysis, and invention.

By the 1980s, we will probably have a space shuttle in operation. The shuttle is a hybrid rocket-airplane that will serve as a reusable launch vehicle for satellites and also carry an earth-orbiting payload for several weeks. One apparatus that the shuttle is scheduled to inject into orbit is a large space telescope with an aperture of about 100 inches. This telescope would give astronomers a crucial look into the nuclei of exploding and ejecting galaxies. A one-meter class telescope could also be operated from the payload bay at the back of the shuttle's control cabin and provide the ultraviolet and infrared data from the dark sky that would be helpful to our fundamental understanding of the uni-

The cost of the shuttle is currently being justified mainly on the grounds of military considerations. I believe that potential scientific results alone would justify the expenditure involved, providing there is no appreciably cheaper way to get equivalent observations. The initially high cost of the shuttle is defended in terms of the many trips the vehicle is scheduled to make to inject satellites into orbit and to monitor orbital instruments. If it would be appreciably less expensive to launch a large space telescope as an independent object-to do one-meter class observations from an orbiting Skylab-then the shuttle would have to be justified on its projected nonscientific uses alone. But it is conceivable that a continuing astronomical research effort from space might eventually require so many missions as to justify, over the long run, the construction of a reusable shuttle vehicle.

In any case, the time may be ripe to consider intensifying rather than cutting back on the quest for basic astronomical data and, perhaps, to begin discussion of the establishment of a National Space Observatory to provide us with the new view of our universe that operations above the terrestrial atmosphere can offer us.

Halton Arp is a research astronomer on the staff of the Hale Observatories in California.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun moves into the constellation Gemini on June 21, into Cancer on July 20, and into Leo on August 10. It rises at the earliest hour of the year about June 13; reaches the summer solstice on June 21; sets at the latest hour about June 27; and is most distant from earth (aphelion)—94,512,000 miles away—on July 5. By the end of July, the duration of daylight has been reduced almost three-quarters of an hour from its maximum.

The moon is in the evening sky generally during mid-month this summer, with a morning crescent moon for the first week and a waning gibbous moon during the last week. Phases in June are first-quarter on the 16th, full moon on the 23rd; in July, last-quarter on the 1st, new moon on the 8th, first-quarter on the 15th, full moon on the 23rd, and last-quarter again on the 31st: in August, new moon on the 7th,

first-quarter on the 13th.

Stars and Planets Venus, the principal attraction in the evening sky this summer, is at its brightest and most conspicuous position in late

June and early July, but leaves the sky rapidly in August.

In the morning sky, Mars is beginning to brighten more rapidly and to rise quite high before dawn. Together with very bright Jupiter, Mars can be seen in the east from about midnight on, easy to locate among the dim stars of Pisces and Aries. Jupiter is always the brighter of the two. The planets are quite close on the evening of June 15–16; Mars separates to the left thereafter.

June 15-16: Mars and Jupiter are in conjunction.

June 18: Venus is at its greatest distance from the sun in the evening sky (greatest easterly elongation).

June 21: Summer begins north of the Equator at 7:27 P.M., EST.

June 22: Mercury resumes normal (eastward) motion. June 29: The moon, at apogee, is farthest from earth.

July 2-4: Mars and Jupiter are near the moon.

July 4: Mercury is at its greatest distance from the sun in the morning sky, but this is an unfavorable elongation.

July 7: Mercury is covered (occulted) by the moon after sunrise.

July 8: Regulus, in Leo, is near Venus tonight. July 11: The moon is at perigee, nearest earth.

July 11-12: The moon is near Venus on both evenings.

July 15: Saturn, in conjunction with the sun, enters the morning sky.

July 21: Venus is at greatest brilliance in the evening sky. July 27: The moon is at apogee, farthest from earth.

July 29: The Delta Aquarid meteor shower reaches maximum, up to 20 meteors per hour.

July 30: Jupiter is near the moon this morning.

August 1: Mars is near the moon this morning. Mercury, at superior conjunction with the sun, enters the evening sky.

August 3: Venus begins its westward (retrograde) motion and will soon leave the evening sky.

August 8: The moon is at perigee, nearest earth.

August 8: The moon occults Venus over the Eastern Hemisphere.

August 11–14: Look for the Perseid meteor shower, the best of the year, during after midnight hours, particularly on the morning of the 12th or 13th.

August 15: Jupiter begins to move retrograde (westerly).

★Hold the star map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 12:25 A.M. on June 15; 11:25 P.M. on June 30; 10:25 P.M. on July 15; 9:25 P.M. on July 31; and 8:25 P.M. on August 15; but it can also be used for about an hour before and after these times.







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NATURAL HISTORY

Incorporating Nature Magazine Vol. LXXXIV, No. 7 August-September 1975 The American Museum of Natural History Gardner D. Stout, President Thomas D. Nicholson, Director

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For six years, Pascal James Imperato lived in West Africa, directing a smallpox eradication program as part of a global campaign of the World Health Organization. His investigation of smallpox outbreaks often took him to isolated villages where he became interested in the social organization and the art forms

of the region (see *Natural History*, December, 1972, and April, 1975). On his return to this country in 1972, Imperato was appointed director of the Bureau of Infectious Diseases of the New York City Department of Health. In 1974 he became first deputy commissioner of the Department.



Intrigued by the adaptability of certain animal species to contemporary environmental changes, John W. Miller focused on starlings because he could study these phenomenally successful birds while walking to the subway on his way to work. An English instructor at Hunter College, he did his field investigations of starling behavior at the 181st Street Bridge over the Harlem River in New York City, the Palisades along the Hudson River, the backyards of friends, along the shoulders of superhighways, and in various McDonald's parking lots. Miller previously wrote "Return of the Beaver," for the June-July, 1972, issue of Natural History.



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"From the moment I first saw a tardigrade clambering about on a sprig of moss, I was hooked," said Diane R. Nelson when asked about the origin of her interest in this microscopic invertebrate. As assistant professor of general science and science education at East Tennessee State University, Nelson has centered her field research in the southeastern United States, primarily on Roan Mountain, Tennessee. For the past two months, however, she has been examining tardigrade ecology in New Zealand, under the auspices of a NATO senior fellowship.

Lynn D. Mason began studying medical anthropology during the summer of 1967 when he visited the Eskimo of the Kuskokwim River in southwest Alaska on a University of California program. Struck by the toll that disease had taken of the population, Mason went back to the region in 1969 to gather material for his doctoral dissertation. Since his return, Mason has taught anthropology at California State University in Northridge. His attention has recently shifted to the study of myth and ritual, and he and his students are currently investigating religious diversity in the Los Angeles area with an emphasis on Zen Buddhism.





A formulator of the theory that Pleistocene mammals became extinct through overkill by human hunters, Paul S. Martin has long been looking into the causes of the disappearance of many species of large animals in a relatively short period of time. His research on the fossil dung of the extinct ground sloth is one aspect of his interest in faunal extinction. With a background in both geology and biology, Martin has worked extensively in the field of paleoecology, and has made research trips to East Africa, Madagascar, Argentina, Mexico, and Central America. A professor of geoscience at the University of Arizona, he wrote "Pleistocene Overkill" for the December, 1967, issue of Natural History.





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The Dubious Gamble **Against Smallpox**

by Pascal James Imperato

This feared virus's persistence and possible adaptability may foil the last campaign of a worldwide war against it

More than any other disease, smallpox has historically been the most feared. It is an ancient affliction, which has killed millions of people and permanently scarred countless others. The worst epidemic on record took place in India in 1944: 320,500 cases and 89,000 deaths were reported.

The disfigurement that results from smallpox may be far more responsible for its fearsome reputation than the deaths it causes. Unlike other viral diseases such as chickenpox or measles, which predominantly infect children, smallpox can strike anyone who has not had the disease or been recently vaccinated. Consequently, there is a large susceptible population. The disease does not usually strike the same person twice owing to the immunological buildup within the body. Vaccination, however, does not confer long-lasting immunity, and complete eradication of the disease using this method is therefore difficult. Even if vaccinations are successful within a given population, missed individuals or faulty administration allow the disease to survive.

Efforts to control the disease first began centuries ago and are still continuing. In 1966 the World Health Organization (WHO) launched a global campaign to erad-



Pascal James Imperato



icate smallpox in the thirty countries where it was then endemic. Today, the disease's prevalence has been greatly reduced, but it is still common in three countries—Bangladesh, India, and Ethiopia.

When WHO launched its massive vaccination campaign in 1966, it predicted the eradication of smallpox within ten years. With the campaign now in its tenth year, the organization still maintains that the disease will be eliminated by the end of this year. If this goal is realized, it will mark the first time that man has successfully eradicated a disease. While modern medical techniques result in the control of many diseases, viruses such as smallpox are particularly tenacious, not only because of the susceptibility of people to the disease but also because of the physical difficulty of vaccinating every person who could spread the disease.

Some viruses, for example, that of influenza, are extremely evasive and able to evolve vaccine-resistant forms. Some have the capability of infecting animal populations without causing disease symptoms in the animal, thus creating a large viral reservoir that can infect man. Although

The smallpox eradication program in Mali took five years and was accomplished by medical teams that traveled from village to village in an effort to vaccinate all susceptible people.

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much is unknown about smallpox, it does show some indications of the latter characteristic.

We do not know exactly when or where smallpox originated. The mummy of Ramses V, an Egyptian king who reigned from 1160 to 1156 B.C., bears scars that could be evidence of smallpox, but they also could have been caused by chickenpox. Smallpox was first described in A.D. 910 by Rhazes, a Persian physician. Traders from the Mediteranean probably introduced the disease into Europe and by the tenth century it was well established there.

The virus was reportedly brought to the New World and transmitted to the Aztecs by one of Cortes's soldiers. From what is now Mexico, the disease spread throughout the Americas, aided by later traders and settlers from Europe who infected Indians in both North and South America. The first known severe epidemic in North America practically decimated the Algonquin Indians in 1616 and 1617. By the eighteenth century smallpox was present throughout the world and epidemics occurred regularly in Europe and the Americas. Until 1934, there were thousands of cases each year in the United States. In that year a national campaign to vaccinate children began, and by 1947 only 173 cases were reported. The last case in this country occurred in 1949.

The disease has three forms: variola major, variola minor (also known as alastrim), and an intermediate form-common in West Africa until its recent eradication but still found in East Africa. All three forms are closely related variants of the same disease, which may have shifted genetically over time. The symptoms produced by the variants tend to be similar and the three forms cannot be differentiated except in a laboratory. Even then, the intermediate form is often indistinguishable from variola major. Whereas the symptoms of the three forms are similar, the effects are sometimes quite different: variola major is fatal to about 50 percent of those afflicted; the fatality rate of the intermediate form is about 8 percent of those infected; and that of variola minor, about 2 percent. Although it can be extremely severe, some cases of variola minor are so slight that they are never diagnosed as smallpox. Spanish soldiers introduced this variant into Central America in the sixteenth century, and for an unknown reason, it has remained more prevalent in the Americas than the

other two variants.

Regardless of its form, smallpox is transmitted in the same way as the common cold—by virus particles carried through the air from host to host. Once in a human host the virus follows an established course. It first passes to the lung tissues, then rapidly spreads to the spleen, liver, and lymph nodes where it remains for ten to twelve days. During this incubation period, the virus multiplies, but the infected person has no symptoms. In the next stage—the prodromal period—the virus invades the bloodstream in large numbers, and the victim suffers from chills, fever, headache, backache, and nausea. In this three- or four-day period the virus courses through the bloodstream and spreads to other tissues, including the respiratory tract, from where it exits in large numbers. The droplets produced by coughing, sneezing, and speaking are heavily laden with virus particles, which gain easy access into the noses and mouths of individuals in contact with the patient, infecting those who have not already developed antibodies against the virus and, hence, immunity from the disease, either through prior contraction or by vaccination.

Because the disease is maximally transmitted for such a short time, its spread is slow and will take place primarily when an infected person in the prodromal period is near a susceptible person. The likelihood of this is reduced, however, because of the symptoms of the disease during this stage: a person suffering from nausea, fever, chills, and aches is not apt to be with many other people.

A 1970 outbreak of smallpox in a hospital in Meschede, West Germany, exemplified the highly infectious state of the disease during the prodromal period. A young man who had returned from Pakistan ten days earlier came down with what were thought to be typhoid symptoms and was admitted to the Meschede hospital's isolation ward where security was very rigid. A few days later the disease was diagnosed as smallpox. After a ten-day period, seventeen patients, nurses, and visitors who had been on three floors of the isolation ward came down with the disease and four died. None of them had had any contact with the patient suffering from smallpox.



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Vivitar Series 1 70-210mm f3.5 macro focusing zoom lens. Several months later, the mystery of how these people became infected was solved. To test the path of air currents from the original victim's room through the rest of the ward, experimenters released smoke that diffused from the room, along the ground floor corridor, and up the stairwells to the second and third floors, probably the same route along which the virus was borne.

After the short prodromal period, the virus leaves the bloodstream and, for reasons that are not clear, enters the epidermal cells of the face and extremities causing a rash in these areas. Each red spot of the rash soon develops into a pimplelike lesion that forms a pus-filled head. Over the course of a week to ten days, these pustules mature and scabs form. When these fall off, they leave deep pits and scars in the skin. The entire clinical course of the disease lasts about three weeks.

Because the burst pustules and fallen scabs contain a large amount of virus, a smallpox patient's bed sheets, the objects he touches, and even dust particles near him can all become virus laden. In 1923, a smallpox outbreak occurred in London among chambermaids who had handled infected bed linen. Outbreaks also often occurred among launderers who sorted out soiled clothing and linen. The laundering process, however, apparently kills the virus; those who ironed the washed garments did not contract the disease.

The smallpox virus can live for several months in scabs. Among the Yoruba people of Nigeria and Dahomey, priests of the Shopana cult (named for the god of smallpox and other diseases) rubbed a powder made from smallpox scabs on the foreheads of worshipers during rituals. The same priests treated smallpox cases and were responsible for the disposal of those who died from the disease. As payment for their services, the priests were entitled to a large portion of the personal possessions of the victims. Not too much is known about the cult, but it would appear that it was in the priests' interests to keep the disease alive. In light of this, the British banned the cult in 1917.

Where the disease has been endemic for long periods, smallpox scabs and the fluid from pustules have been used to control the disease, a technique that intrigued Europeans when

they first learned of it in the eighteenth century from Africans and Asians. The purpose of variolation, as the practice is known, is to induce either a localized reaction or a mild case of smallpox, both of which result in the production of antibodies and thereby protect an individual from a possibly fatal, naturally acquired infection. The Chinese practiced variolation by inserting powdered scabs into the nostrils. In Mali, the tip of a knife blade, a thorn, or a bird feather covered with pus from a smallpox pustule was inserted into the skin. Variolation was common in West Africa until 1971 when an extensive vaccination program, in which I took part, led to the eradication of the disease from this area.

Variolation was introduced to this country in 1716 by Onisemus, a North African slave, who described the technique to his master, the Puritan theologian Cotton Mather. Mather resolved to use the method in Boston during the 1721 smallpox outbreak, which resulted in 6,000 cases and 855 deaths. The local clergy and legal authorities tried to prevent him from proceeding, but he persuaded a physician to variolate 242 people. Only six of these died.

At about the same time, variolation gained acceptance in Europe through the efforts of Lady Mary Wortley Montague, the wife of the British ambassador to Turkey. Against the wishes of the conservative London medical establishment, Lady Mary had her daughter variolated during an epidemic in London. Through her influential contacts with British nobility, a variolation experiment was conducted on six prisoners at Newgate Prison. Not only did the prisoners escape the disease but they also were granted pardons because of their willingness to serve as guinea pigs.

Some fifty years after variolation came into common practice in Europe and America, another smallpox control technique was discovered, one that revealed the possible adaptability of smallpox virus and led directly to the discovery of smallpox vaccine. British farmers had long observed that cows often developed lesions on their udders—a disease known as cowpox-and that those who milked the cows and developed similar-appearing lesions on their hands never contracted smallpox. In 1774, Benjamin Jesty, a Dorset dairy farmer inoculated his

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The Slow Spread of a Smallpox **Outbreak Along the Niger River**

On February 12, 1967, eight-year-old Mamadou Dabala and his parents leave the village of Tellaberi and begin traveling up the Niger by canoe. Two days later, Mamadou (who is in the prodromal stage of smallpox) develops a slight

	Hounkoum	Kounsoum	Lellehoi
February 16 Day 5	The family arrives in Hounkoum and spends the night with a fisherman and his 4 children		to Tellab Republic of N
February 18 Day 7		Mamadou and his family spend the night with a family that has 1 child	
February 19 Day 8			Mamadou arrives in his home village, where many people are exposed to him.
March 3 Day 25	Fisherman's 4 children develop smallpox rashes		Mamadou dies
March 6 Day 28		Child exposed to Mamadou develops a rash	
March 7 Day 29			5 children, in family living next to Mamadou's, develop rashes
March-April	3 more cases occur	11 more cases occur	54 more cases occur
Total new cases February-April	7	12	59

• Lellehoi

Kounsoum

wife and two children during a local smallpox outbreak by scratching fluid from a cowpox lesion into their skin. The inoculations were successful: the fluid apparently caused the production of antibodies against smallpox.

In 1796, Edward Jenner, a Gloucestershire physician, also used fluid from a cowpox lesion to show its definite potential for preventing smallpox. In an ethically questionable experiment, he inoculated an eight-year-old boy with cowpox fluid and, seven weeks later, variolated the boy with material from a smallpox lesion. If the cowpox fluid did not produce antibodies to fight the smallpox virus, the boy would probably come down with a light case of smallpox or at least a local reaction to the variolation. There was no reaction; the subject did not develop any symptoms of smallpox. Jenner referred to his experiment as vaccination-from the Latin vaccinus, meaning "pertaining to cow" -and submitted a paper on it to the Royal Society, which rejected it. He consequently had the paper published at his own expense, which resulted in the practice of vaccination quickly spreading throughout Europe and America.

The smallpox vaccine used today is produced by inoculating calves with a virus similar to smallpox and then collecting the material from the subsequent lesions on the calves' skin. Vaccination generally protects for an average of three years, but this length of time is highly variable. Occasionally a vaccination will last up to twenty years. In India, however, some people have contracted the disease a year after having been vaccinated.

Until the mid-1960s, vaccine preparations could not tolerate the high temperatures of the tropics; the virus was quickly killed and the vaccine was useless. In some parts of Africa, smallpox often occurred among people who had recently been vaccinated. Understandably, many segments of the population came to believe that the vaccinations were useless and reverted to variolation. As long as vaccines were so fragile, there was little hope of controlling the disease, much less eradicating it.

Hounkoun

A technical breakthrough occurred, however, when a number of researchers discovered that the vaccine would remain effective for long periods if it were freeze-dried and vacuum sealed. At the same time, the automatic jet injector, a technological innovation that injects vaccine into the skin under hydraulic pressure and without needles, brought efficient smallpox control into the realm of possibility. With this instrument, up to one thousand injections per hour can be given.

Supported by this technology, the World Health Organization in 1966 predicted the eradication of smallpox within a ten-year period and began to sell the idea to the thirty countries where the disease was still endemic. Some of these countries, especially those in Africa, objected, saying that smallpox eradication should not take precedence over the control of other, more harmful diseases. They eventually agreed to support the smallpox program only when assured that a measles control program would also be implemented.

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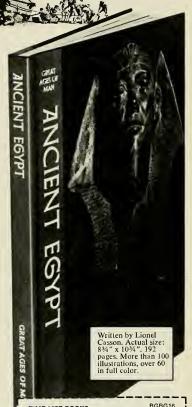
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In 1966, the U.S. Agency for International Development (AID), in cooperation with WHO, launched a massive smallpox eradication program in West and Central Africa. Some 120 million people in twenty countries were vaccinated at a cost of fifty million dollars. Since 1971 there have been no known cases of smallpox in these countries.

During the same period mass vaccination programs were launched in South America and Indonesia; the last known cases of smallpox occurred in South America in early 1971 and in Indonesia in 1972.

Because of the persistence of the disease in Ethiopia and in the countries of the Indian subcontinent, the eradication predictions of WHO will probably not be realized by the end of 1975. In 1974, some 218,000 smallpox cases occurred in these countries; 188,000 in India alone. By the end of April of this year, only 9,551 cases had been reported to WHO and most of these were in Bangladesh. This dramatic decline was achieved because WHO poured in hundreds of advisers and spent millions of dollars to assist the thousands of native smallpox program

The maintenance of this high level of activity is crucial for the eradication of smallpox. Because of the tenacity of the disease, eradication efforts must remain consistent. Political upheaval, social instability, or economic insecurity can quickly reverse the downward-curving occurrence of the disease. Natural phenomena can also upset the trend.

In January of this year, there were 990 smallpox cases in Bangladesh; one month later, the number had jumped to 1,700. The upsurge was blamed on extensive flooding during 1974 when thousands of people were uprooted from their homes and forced to travel through the country in search of food and shelter, thereby spreading the disease and making mass inoculations all but impossible.

In some areas of countries where the disease is still endemic, rapid transportation facilities and access to isolated villages are nonexistent. It is in these remote areas that smallpox can persist—passed from one settlement to another by people traveling along mountain trails.

To achieve zero reported cases of smallpox is not the same as eradicating the disease. In accordance with standards established by WHO, an international commission must visit an area two years after the last known case is reported and verify that the disease has been eliminated. Such commissions have already declared smallpox eradicated in South America and Indonesia. But smallpox has not been declared eradicated in Africa because the disease is still present in Ethiopia.

To achieve this goal, hidden cases must be sought out. Secluded mountaintop villages in Ethiopia will have to be reached, no easy task in a country now in the throes of great political upheaval. And in Bangladesh, Pakistan, and India, surveillance teams will have to search thousands of villages.

Even after eradication in an area has been achieved, the trend may suddenly be reversed by just one infected person if vaccination measures are not maintained. During the period from 1950 to 1971, forty-nine cases of smallpox were brought into Europe—where the disease has long been eradicated—and resulted in 680 infections. In most cases, those who contracted the disease did not have up-to-date vaccination protection.

The last major European outbreak occurred in 1972 in Yugoslavia. The initial case was brought into the country by a Yugoslav Muslim returning from Mecca, who had apparently contracted the disease in Iraq. His infection resulted in 173 cases in Yugoslavia, 33 of which were fatal, over a seven-week period. During the outbreak more than nine million people received vaccinations.

Because the disease has been eradicated in the United States since 1949 and because vaccinations often produce severe side effects such as encephalitis and serious skin lesions, routine smallpox vaccinations were discontinued in this country in 1971. There is now a large susceptible population and, as in the Yugoslavian outbreak, just one infected person could bring the disease into this country. Although those coming into this country must have validated smallpox vaccination certificates, these can easily be forged.

In addition, revaccination often does not produce antibodies as effectively as does the original vaccination; a person coming into this country with a valid smallpox certificate could nonetheless be carrying the disease. In readiness for this possibility, New York City keeps six million doses of vaccine on hand.

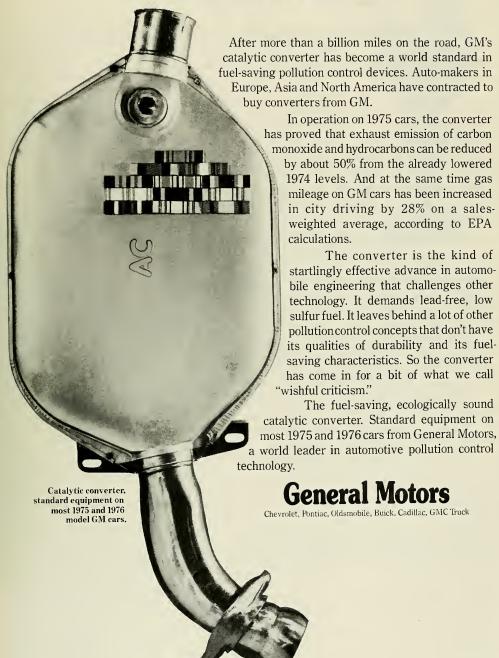
In India, researchers have recently discovered an even more alarming way in which the disease can be transmitted—by healthy people who act as carriers. Ten percent of the population of an area-a very large percentage medically-were found to be carrying the virus in their throats. All of these people were immune to the disease due to the presence of antibodies in their bloodstreams. The virus was able to survive only in throat mucus because of the lack of antibodies there. The implications of this finding are not yet known, but they indicate the survival ability of the virus.

Even if smallpox is eventually eradicated as a disease of man, the virus or its variations could continue in animal populations and, at some later date, reinfect man. Two orangutans in an Indonesian zoo became infected with smallpox in 1949 during an outbreak in that country. Although such occurrences are rare, the capability is apparently present.

In 1970 and 1971, after the completion of the U.S. AID-WHO smallpox eradication program in Central and West Africa, thirteen cases of a disease clinically indistinguishable from smallpox were reported. Four deaths resulted. Laboratory investigations indicated that the disease was monkeypox, a virus first identified in 1958 in cynomolgus monkeys. Since then, WHO has reported ten cases of monkeypox in cynomolgus monkeys in zoos and laboratories, but these cases have not infected anyone having contact with the monkeys. The origin, as well as the transmittal, of monkeypox is still not known, but some researchers theorize that it may be a variant of smallpox that long ago adapted to monkeys.

If monkeypox and possibly cowpox do turn out to be variants of smallpox, the findings will indicate that smallpox virus has some survival tactics about which we know very little indeed. There are other, unknown aspects to smallpox, which might well enable the virus to persist long after the 1975 eradication deadline has passed. If man has never been able to eradicate a disease, there is no reason to suppose that smallpox, which appears to have several survival tricks, will fall an easy victim to eradication efforts.

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Letters

The Waning West

"The Waning of the West" by Stan Steiner is an excellent article [June-July, 1975]. Unfortunately, it will evoke no response.

The American West will die and turn to true desert as surely as the same fate befell much of northern Africa, Persia, and central Arabia. It will go from a semiarid to an arid state for the same reason those other regions were transformed into desert: human greed and folly.

HARRY M. CAUDILL Whitesburg, Kentucky

While "The Waning of the West" made several good points, it neglected one that is obvious to many of us who live in "cow country." Cattle have stripped, and continue to strip, the land, although more slowly and less dramatically than strip miners. The ecology of the West, particularly of the southwestern deserts, has been radically altered by grazing cattle. The Bureau of Land Management estimates that 83 percent of the land it controls is in bad, poor, or fair condition as a result of grazing mismanagement.

Like coal being shipped "back East," cattle travel by rail and truck from the ravaged West to the hungry millions. Our grass—and with it our ecosystem—becomes steak, stew, and dogfood to fatten the already overstuffed city residents. Along with "Let the bastards freeze in the dark," some might add, "Let them go without beef."

KEN KINGSLEY Wickenburg, Arizona

In the well-written essay "The Waning of the West," the author states, "One official of the Western Electric Company told the newspapers [it] might become the largest power project in the world. . . ." This would appear to be in error.

I believe you will find that "Western Electric Company" has been the copyrighted name of the manufacturing and supply unit of the Bell System for most of this century. Though we are accused by the FCC and Justice Department of doing a lot of bad things, two that we don't do are strip mining and power generating.

D.J. SHEARER Western Electric Aurora, Colorado

EDITOR'S NOTE: We did not mean to add to the list of accusations against Western Electric; the company in question is Western Energy, a subsidiary of the Montana Power Company.

Endangered Research

The article by R. D. Martin on the "Ascent of the Primates" [March, 1975] was charming. The pictures of the prosimian primates were particularly splendid. I thought it might interest your readers to learn that the largest and most varied research group of prosimian primates is in danger of extinction. The Duke University Primate Facility, which I founded a number of years ago, is no longer able to elicit support from the University. The colony was begun with grants from the National Science Foundation and a variety of other research grants, including some from the National Institutes of Health. Duke University undertook to house the colony and find money for its support when I moved there from Yale University.

This colony consists of a variety of important and interesting species, most of which are on the endangered list. The present census of the colony is about 225 and contains the following: two species of bushbabies; eight species or subspecies of Lemur; Hapalemur; Propithecus; Microcebus; and Cheirogaleus.

The dedicated staff has been able to persuade the animals to breed successfully. Every species has produced offspring, and we have five generations in certain lineages. There are a variety of important research programs involving the animals threatened by the extinction of the colony.

The prospects are grim and I believe that your readers should be aware that an important resource is about to become extinct.

> JOHN BUETTNER-JANUSCH New York, New York



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Man and Other Animals

"The Western world has yet to make its peace with Darwin and the implications of evolutionary theory"

In Alexander's Feast, John Dryden describes his hero, besotted after dinner, retelling the tales of his martial glory:

The King grew vain;
Fought all his battles o'er
again;
And thrice he routed all his foes,
and
thrice he slew the slain.

One hundred and fifty years later, Thomas Henry Huxley invoked the same image in declining to pursue further the decisive victory he had won over Richard Owen in the great hippocampus debate: "Life is too short to occupy oneself with the slaying of the slain more than once."

Owen had sought to establish the uniqueness of man by arguing that a small convolution of the brain, the hippocampus minor, was absent in chimps and gorillas (and all other creatures), but present in Homo sapiens alone. Huxley, who had been dissecting primates while preparing his seminal work, Evidence as to Man's Place in Nature, showed conclusively that all apes had a hippocampus, and that any discontinuity in the structure of primate brains lay between prosimians (lemurs and tarsiers) and all other primates (including humans), not between man and the great apes. Yet for a month, in April, 1861, all England watched as her two greatest anatomists waged war over a little bump on the brain. Punch laughed and versified; and Charles Kingsley wrote at length of the "hippopotamus major'' in his children's classic of 1863, *The Water Babies*. If a water baby had ever been found, he commented, "they would have put it into spirits, or into the *Illustrated News*, or perhaps cut it into two halves, poor dear little thing, and sent one to Professor Owen, and one to Professor Huxley, to see what they could each say about it."

The Western world has yet to make its peace with Darwin and the implications of evolutionary theory. The hippocampus debate merely illustrates, in light relief, the greatest impediment to this reconciliation-our unwillingness to accept continuity between ourselves and nature, our ardent search for a criterion to assert our uniqueness. Again and again, the great naturalists have enunciated general theories of nature and made singular exceptions for man. Charles Lyell (see my column of February, 1975) envisioned a world in steady-state: no change through time in the complexity of life, with all organic designs present from the first. Yet man alone was created but a geological instant ago-a quantum jump in the moral sphere imposed upon the constancy of mere anatomical design. And Alfred Russel Wallace, an ardent selectionist who far out-Darwined Darwin in his rigid insistence on natural selection as the sole directing force for evolutionary change, made his only exception for the human brain (and turned to spiritualism late in his life).

Darwin himself, although he accepted strict continuity, was reluctant to expose his heresy. In the first edition of the *Origin of Species* (1859), he wrote only that ''light will be thrown on the origin of man and his history.'' Later editions added the intensifier ''much'' before

the sentence. Only in 1871 did he gather the courage to publish *The Descent of Man*.

Chimps and gorillas have long been the battleground of our search for uniqueness; for if we could establish an unambiguous distinction-of kind rather than of degree-between ourselves and our closest relatives, we might gain the justification long sought for our cosmic arrogance. The battle shifted long ago from a simple debate about evolution: educated people now accept the evolutionary continuity between man and ape. But we are so tied to our philosophical and religious heritage that we still seek a criterion for strict division between our abilities and those of chimpanzees. For, as the psalmist sang: "What is man, that thou art mindful of him? . . . For thou has made him a little lower than the angels, and hast crowned him with glory and honor." Many criteria have been tried, and one by one they have failed. The only honest alternative is to admit the strict continuity in kind between ourselves and chimpanzees. And what do we lose thereby? Only an antiquated concept of soul to gain a more humble, even exalting vision of our oneness with nature. I propose to examine three criteria for distinction and to argue that, on all accounts, we are more nearly akin to the chimpanzee than even Huxley dared to think.

1. Morphological uniqueness in the Owenian tradition. Huxley permanently dimmed the ardor of those seeking an anatomical discontinuity between man and ape. Still, the search has continued in some quarters. The differences between adult chimps and people are not trifling, but they do not arise from any difference in kind. Part by part, order

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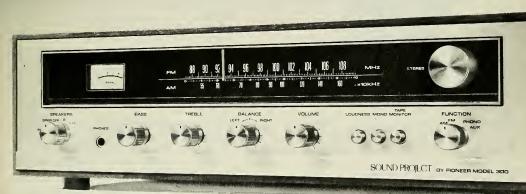
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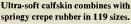




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by order, we are the same; only relative sizes and rates of growth differ. With the painstaking attention to detail so characteristic of German anatomical research, Prof. D. Starck and his colleagues have recently concluded that differences between the skulls of humans and chimps are quantitative only.

2. Conceptual uniqueness. Few scientists have strongly pushed the anatomical argument since Owen's debacle. Instead, the defenders of human uniqueness have posited an unbridgeable chasm between the mental abilities of man and chimp. To illustrate the gap, they have sought an unambiguous criterion of distinction. An earlier generation cited tool use, but clever chimps employ all sorts of artifacts to reach inaccessible bananas or release im-

prisoned mates. More recent claims have centered on language and conceptualization, the last bastion for potential differences in kind, Early experiments on teaching chimps to talk were notably unsuccessful-a few grunts and a trifling vocabulary. Some concluded that the failure must reflect a deficiency in cerebral organization, but the explanation seems simpler and far less profound (although by no means unimportant for what it implies about the linguistic capabilities of chimps in natural conditions): the vocal cords of chimpanzees are constructed in such a way that large repertories of articulated sounds cannot be produced. If we could only discover a different way of communicating with them, we might find that chimps are much smarter than we think.

By now, all readers of newspapers and watchers of television have learned of the striking initial successes of communicating with chimps via the sign language of the deaf and dumb. When Lana, star pupil of the Yerkes Laboratory, began to ask for the names of objects she had not previously seen, can we any longer deny to chimps the capacity to conceptualize and to abstract? This is no mere Pavlovian conditioning. R.A. and B.T. Gardner have recently reported their first results on two baby chimpanzees raised with sign language from the day of their birth (Science, February 28, 1975). (Washoe, a previous subject, was not exposed to sign language until she was a year old. After six months of training, her

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Deep-sky object M81 photographed from Burns, Oregon by Hubert Entrop with his Questor 3½. Enlarged from 35 mm. negative; I hour 45 min. expasure at f/10. Much of the delicate spirol, so beautiful an the print, is lost here in the reproduction

LETTER TO QUESTAR ON PERFORMANCE

wner, Dick McCorrick, who lives in Arizona:

"It has been a little over a year since I received my luestar, so I thought I'd send you this note on its perrmance.

"First, let me describe the sky conditions here: my ome is one of the poorest abserving sites in the State. he city of Phoenix lies just four miles to the west, while empe, with 50,000 inhabitants, is two miles due south mmediately to the north is Scottsdale, population 0,000, while eight miles to the east is Mesa, 70,000. ou can then understand why artificial skyglow is such problem, and when smag sets in the situation is much

"Considering these handicaps the Questar has perormed remarkably well. My favorite objects are deepcy clusters and nebulae: despite the light sky I have anaged to view forty messier objects, with the dimmest eing tenth-magnitude M100. The haurs before dawn, hen graund lights and smog are ot a minimum, ore the

est time far this sort of observing.
"Needless ta say, whenever the opportunity arises, lake the Questar with me to observe in really dork skies. in one traut fishing trip I viewed M42 and was amozed to see the faint trailing nebulosity run off the field of ew in the 24-mm. eyepiece. On onother trip, this one is Mexica, I saw Omega Centauri in brilliant splendor. xperiences such as these make me hesitant to resume ormal observing at my home!

"The moon and planets are usually good sights, even ere. My favorite is Soturn. On one particularly steady ight I boosted the magnification to 400x with no loss

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vocabulary consisted of only two signs.) Both baby chimps began to make recognizable signs in their third month. One, Moja, had a fourword vocabulary in her thirteenth week: come-gimme, go, more, and drink. Their current progress is no slower than that of a human child. We generally wait for words and do not realize that our babies signal us in other ways long before they speak. I do not believe that our mental differences with chimps are merely a question of nurturing. 1 have no doubt that the progress of these baby chimps will slow down relative to the growing achievements of human babies. The next president of our country will not belong to another species. Still, the Gardners' work is a striking demonstration of how we have underestimated our closest biological relatives.

3. Over-all genetic differences. Even if we admit that no single feature or ability completely separates humans and chimps, at least we might be able to affirm that the overall genetic differences between us are tolerably great. After all, the two species look very different and do very different things under natural conditions. (For all the quasi-linguistic capacity shown by chimps in the laboratory, we have no evidence of rich conceptual communication in the wild.) But Mary-Claire King and A.C. Wilson have just published an account of genetic differences between the two species (Science, April 11, 1975), and the results may well upset a prior prejudice still carried, I suspect, by most of us. In short, using all the biochemical techniques now available and surveying as many proteins as possible, the over-all genetic differences are

remarkably small.

When two species scarcely differ in morphology but function as separate and reproductively isolated populations in nature, evolutionary biologists speak of "sibling species." Sibling species generally display far fewer genetic differences than pairs of species placed in the same genus but clearly different in morphology ("congeneric species"). Now chimps and people are obviously not sibling species; we are not even congeneric species by conventional taxonomic practice (chimps belong to the genus Pan; we are Homo sapiens). But King and Wilson have shown that the over-all genetic distance between man and chimp is less than the average for sibling species and far less than in any tested pair

of congeneric species.

A fine paradox, for although I have argued strongly that our distinctions are matters of degree only, we are still very different animals. If the over-all genetic distance is so small, then what has caused such a divergence in form and behavior? Under the atomistic notion that each organic trait is controlled by a single gene, we cannot reconcile our anatomical dissimilarities with King and Wilson's findings, for many differences in traits would have to reflect many differences in genes.

The answer must be that certain kinds of genes have far-reaching effects-they must influence the entire organism, not just single traits. A few changes in these key genes might produce a great divergence between two species without much over-all genetic differentiation. King and Wilson therefore seek to resolve the paradox by attributing our differences with chimps primarily to mutations of the regulatory system.

Liver cells and brain cells have all the same chromosomes and all the same genes. Their profound difference does not arise from genetic constitution, but from alternate paths of development. During development, different genes must be turned on and off at different times in order to achieve such disparate results from the same genetic system. In fact, the whole mysterious process of embryology must be regulated by exquisite timing in the action of genes. To differentiate a hand from a homogeneous limb bud, for example, cells must proliferate in some areas (destined to be fingers) and die in others (the spaces between them).

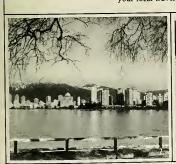
Much of the genetic system must be devoted to setting the timing of these events—to turning genes on and off-rather than to the determination of specific traits. We refer to genes that control the timing of developmental events as the regulatory system. Clearly, change in a single regulatory gene can have profound effects upon the entire organism. Delay or accelerate a key event in embryology and the whole course of future development may be changed. King and Wilson therefore suppose that the primary genetic differences between men and chimps lie in this all-important regulatory system.

This is a reasonable (even necessary) hypothesis. But do we know



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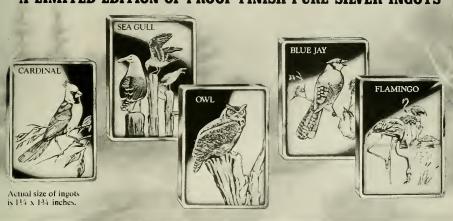
anything about the nature of this regulatory difference? We cannot now identify the specific genes involved; hence, King and Wilson express no opinion. "Most important for the future study of human evolution," they write, "would be the demonstration of differences between apes and humans in the timing of gene expression during development." But I believe that we do know the basis of this change in timing. As I argued in my column for May, Homo sapiens is basically a neotenic species; we have evolved from apelike ancestors by a general retardation in developmental rate. We should look for regulatory changes that slow down the ontogenetic trends we share with all primates (relative decrease in brain size, increase in jaw size, backward migration of the foramen magnum) and allow us to retain juvenile growth tendencies and proportions.

The very low genetic distance between humans and chimps might tempt us to try the most potentially interesting and ethically unacceptable scientific experiment I can imagine-to hybridize our two species and simply to ask the offspring what it is like to be, at least in part, a chimpanzee. I am delighted to report that this almost certainly cannot be done. The genetic differences are small, but they include at least ten large inversions and translocations. An inversion is, literally, a turning around of a chromosomal segment. For two species to hybridize, their chromosomes must be able to pair (lie side by side) before cell division so that corresponding genes can match up one to one: that is, each chimp chromosome must pair with its corresponding human homologue in the hybridized cell. But if part of a human chromosome is inverted relative to its chimp homologue, then the gene-by-gene paring cannot occur without an elaborate looping and twisting that usually precludes successful cell division.

So we will not be able to evoke responses from chimps by infusing into them enough human genes to provide the basis for conventional dialogue. Yet with such remarkable progress in our interspecific communication, who knows? We may be able to learn everything we want to know from the chimps themselves.

Stephen Jay Gould teaches geology at Harvard University.

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The Prodigal Leaf

Plants in nonarid regions use and lose huge amounts of water

On the face of it, plants are water wastrels. A single corn plant contains about two liters, or slightly more than two quarts, of water, but during the course of its growth, it probably removes about one hundred times that amount from the soil. Most of the water is simply evaporated into the air. An acre of corn would thus use about 1,200 metric tons of water during a growing season, the equivalent of an eleven-inch rainfall. Such a prodigal use of water can be dangerous, even lethal, to plants growing in areas of limited moisture.

Why such low efficiency in the use of water? It has to do with the architecture and function of the leaf. The main job of the leaf is nutritional, for it is in the leaf that carbon dioxide and water, catalyzed by light energy, interact to form oxygen and various organic compounds in the process of photosynthesis. In this reaction, the energy of the light absorbed by chlorophyll is stored for future use in the form of sugar. The sugar is later oxidized in the process of respiration, which liberates the energy originally stored in the sugar molecules.

In order to perform its job, the leaf has a large flat area (for light absorption), is highly hydrated (leaf

cells are about 90 percent water), and is perforated to permit the passage of gases (carbon dioxide entry and oxygen loss). The leaf is thus something like a wet towel hanging on a clothesline; warmed by the sun and fanned by the wind, it necessarily evaporates large quantities of water vapor. The process of water vapor loss from the aerial parts of plants, called transpiration, is one that most plant physiologists consider harmful or, at best, an inevitable consequence of the photosynthetic mechanism. In effect, to get the benefits of photosynthesis, you have to accept the evils of transpiration.

Not all scientists are happy with this concept. Full of admiration for the efficient design of natural systems, they look for unappreciated benefits brought about by transpiration. One obvious possibility is evaporative cooling. A corn plant in the noonday lowa sun in midsummer receives about 1.5 calories of radiant energy per square centimeter per minute, of which about two-thirds, or one calorie per square centimeter per minute, is absorbed. During a growing season, this amount of energy would be roughly equivalent to that released by burning 200 tons of coal for each acre of corn. Such a prodigious amount of absorbed energy would completely desiccate the plant were it not that each gram of water evaporated absorbs more than 500 calories. Such a heat loss would occur, on the average, once per hour per 100 square centimeters of leaf

surface, and would represent almost 10 percent of all the energy absorbed. When you add to that the energy loss to leaves by reflection, reradiation, and the movement of air, you approach a tolerable heat buildup. Thus, as long as plenty of water is delivered to the leaf, the evaporative cooling produced by transpiration helps keep it from being cooked to death.

Another possible useful function attributed to transpiration is its facilitation of the upward movement of sap in the wood of the stem. For as the leaf blade dries out by transpiration, it pulls water from nearby veins. The many leaves on a plant contrive in this manner to exert a large total "pull" on the continuous water columns in the microscopic tracheids, or tubular cells, and vessels of the woody tissues of the stem. This combined pull is enough to cause sap to rise to the tops of the tallest trees. Since sap contains not only water but also minerals absorbed from the soil and some organic materials produced in the plant, the net effect of transpiration is to speed the upward movement of these dissolved materials from the root to the leaf and ultimately to the tops of trees. In many forests, much of the total amount of available mineral nutrient is found in the stand of trees. This fact is responsible for the slash-and-burn agriculture practiced by some nomadic peoples as a means of restoring minerals to the soil for crop plants.

The plant is not totally helpless in resisting water loss. For one thing, almost all leaves are covered by a waxy, water-impermeable layer called the cuticle, which overlays the epidermis. Water loss is minimal through most cuticles. The bulk of transpiration occurs through stomata, minute openings on the upper and lower epidermis of leaves and some stems. These intercellular pores are bounded by specialized, sausage-shaped epidermal cells, called guard cells, whose changing form determines the degree to which the pore is open. When the guard cells are turgid, or swollen with water, they become crescent shaped; they then touch only at their ends, and the pore between them is fully open. When the guard cells lose water and turn flaccid, they become linear, and the pore is partly or completely closed. These changes in shape are due to the differential thickness of the guard cell walls. Their outer surfaces, away from the pore, are thin. It therefore stands to reason that as the pressure of fluid, or turgor, within the guard cells increases, the thinner outer walls will balloon out, carrying along the inner walls and opening the pore. When these guard cells lose their turgidity, the elastic strength of the thicker inner walls pulls the guard cells back into a linear orientation, and the pore closes again.

A corn leaf has about 100,000 stomata per square inch of leaf surface, or about 15,500 per square



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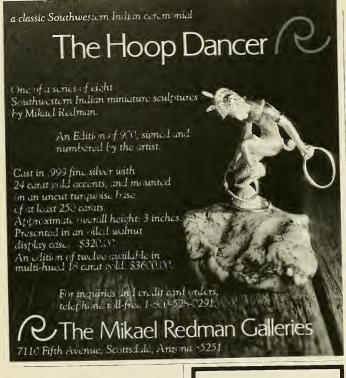
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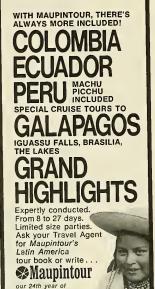
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centimeter. The upper surface of a typical leaf has about 20 percent more stomata than the lower surface per unit area, but both the number and ratio vary with the plant and with the conditions of plant growth, especially humidity and light intensity. In any event, the roughly 200 million stomata on the leaves of a corn plant, each with a pore area of about 4 × 5 micrometers (1 micrometer is equal to a millionth of a meter) provide an open pore space of between 1 and 2 percent of the total leaf area. It is through this space that the movement of carbon dioxide, oxygen, water vapor, and other gases largely occurs.

In a normal day, stomata begin to open at or near sunrise, remain open during most of the day, and close in the late afternoon or early evening. Part of the opening and closing is regulated by the availability of water, part by light, and part by variation in the osmotic concentration, that is, dissolved salts and organic materials, in the watery vacuoles, or central storage tanks, of the guard cells. In general, the osmotic concentration of guard cells is at least twice that of the surrounding, ordinary epidermal cells, but it goes up and down with the change in conditions around the plant.

The main osmotic component of guard cells is known to be potassium chloride. The content of this material tends to be high in the light and low in the dark, but it can also vary rhythmically and in response to plant hormones. One such hormone, abscisic acid (see "Turning Plants Off and On," Natural History, November, 1973), is especially important. When the concentration of abscisic acid is high, potassium chloride leaves the guard cells. The resultant loss of osmotically active material causes a loss of turgor pressure, the closing of the stomata, and a diminution in the rate of transpiration. That these changes may be important in the physiology of the plant is shown by the fact that when a plant starts to wilt, its content of abscisic acid may rise tenfold in a few minutes. This rapid increase in abscisic acid in response to water stress may serve to shut down evaporative water loss in time to prevent excessive desiccation injury and death. The source of the extra abscisic acid, which appears so suddenly, is not yet known, but because of the swiftness of the change, it is believed to be released from some

Paradoxically, partial closure of the stomata does not result in a proportional diminution in transpiration, since evaporation of water from spaced pores is proportional to the perimeter, not the area, of the pores, and perimeter does not change drastically with diminution of the pore from fully to half open. It is only when the pores are virtually closed that transpiration is measurably cut.

The action of light in causing the opening of stomata is intimately related to the concentration of carbon dioxide gas in the intercellular spaces just below the stomata. In normal air (.03 percent carbon dioxide) the guard cells are flaccid and the stomata are closed. When light hits the leaf and photosynthesis starts, the CO2 concentration in these gas spaces is lowered, and the guard cells start to open. This goes on progressively until the CO2 concentration is down to about .01 percent; further diminution in CO2 results in no additional stomatal opening.

In extremely arid conditions, where excessive water loss readily leads to death, cultured plants must be irrigated, and wild plants must be well adapted to the environment to minimize water loss and maximize water uptake. Such adaptations include an extensive root system; a heavy, waxy leaf coat; and a diminished leaf area, so that fewer stomata are exposed to the evaporative forces of the habitat. Some xerophytes, or plants adapted to arid conditions, have no leaves at all, and their photosynthesis is restricted to the green and often fleshy stems. Those stomata that exist in these plants are sunk beneath the stem surface in depressions that minimize water evaporation through air movement.

In a world short of water and food, cultivation of arid zones might become more possible through the use of some technological control of transpiration. One thought is to cover plants with a plastic spray or sheet that would permit passage of carbon dioxide and oxygen but restrain or prevent passage of water vapor. The development of such a material would doubtless make the discoverer rich as well as renowned as a benefactor of mankind.

Columnist Arthur W. Galston teaches biology at Yale University.



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Much Ado About Starlings

by John W. Miller

When admirers of Shakespeare introduced this bird to the American way of life, no one expected such a successful performance

On winter afternoons in Fort Campbell, Kentucky, no one leaves wash on the line after 4:30 P.M. And for fifteen minutes before sunset, flights in and out of the 101st Airborne Division's field are halted as great swarms of starlings, joined by a large component of grackles and scatterings of cowbirds and redwinged blackbirds, some seven to ten million birds in all, gather to roost in a nearby twenty-acre pine grove. The tall trees ring with the metallic, factorylike din of the birds' cries, boughs bend under their weight, and droppings rain on the ground.

Over the last five years this huge mob of wintering blackbirds has swelled from a few thousand to its present numbers. To reduce this vast bird population, the Army has tried various methods—shotguns, propane cannon boomers, taped starling 'distress calls,' thinning the groves where the birds roost, spraying the birds with the chemical detergent

Tergitol—but so far, none has been completely successful.

The starling phenomena in the United States goes far beyond a private war between the Army and invading birds. Indeed, within a fiftymile radius of Fort Campbell there are some seven similarly large roosts that by day spread out and forage in hog troughs, in fields of winter wheat, in lawns, and along roadsides. Although not as enormous as those annually reported in the belt of warmer states from Maryland and Virginia west to Nebraska and Kansas, winter roosts are found in almost every northern state, with perhaps the exception of parts of Maine, Minnesota, North Dakota, and Montana. Neither summer nor winter birds, starlings straddle the vast northern latitudes of frozen but relatively snow-free land, seeking out protected roosts within range of food. Come early April, all roostsnorth and south-are abandoned to all but a small fraction of resident birds, while the great mass of starlings either scatter to local nesting sites or migrate to breed in the northern United States and Canada.

Behind these great blizzards of birds, there is an ornithological saga. It started on March 6, 1890, when

Eugene Scheifflin, a member of the Acclimatization Society—one of many groups of the time that enthusiastically introduced exotic species into the New World—released eighty European starlings in New York City's Central Park with the high-minded intention of acquainting Americans with all the birds mentioned by Shakespeare.

Since that introduction, starlings have outcompeted a number of native birds and, in post-World War II years, have adapted so well to automobile culture, urban and suburban living patterns, mechanized methods of farming—in short, to an energy-intensive way of life—that they are now probably the most numerous bird species in this country.

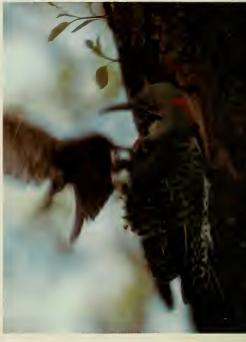
Several of the eighty starlings that Scheifflin released began to nest in Central Park. On April 25, 1891,

As evening approaches, starlings that have flown in from the suburbs perch on a sign over an entrance ramp to the Cross-Bronx Expressway in New York. In a few minutes they will join a large winter roost under one of the bridges in this traffic complex.

John W. Miller







Scheifflin imported forty more, and shortly after, twenty of the exotic birds were reported living in Staten Island, across the bay from Manhattan. In 1896 others were seen in Brooklyn, and by 1898 flocks had become well established to the east as far as Stamford, Connecticut, and to the west at Plainfield, New Jersey. Ten years later they had expanded forty miles out on Long Island, up the Hudson River to Ossining, New York, and across New Jersey to Pennsylvania and Delaware.

As the novelty of the starlings' presence began to wear off, however, bird lovers came to understand the threat that these birds presented to native species. Unlike other cavity-nesting birds-flickers, bluebirds, wrens, tree swallows, martins, and others-which eat only insects and migrate south in the winter, starlings can thrive through the winter in northern latitudes on seeds and grains. Overwintering populations of starlings often preempt available nest hollows that would otherwise be used by migratory cavity-nesting species. Moreover, even if flickers and other woodpeckers do dig out new nesting cavities in dead trees, starlings will oust them, eggs and all. Considering that different starlings can evict a flicker two or three times in a nesting season and that a starling lays from four to six eggs, a flicker could conceivably provide nesting space for eighteen to thirty-six starling fledglings, depending on whether one or two broods are raised. Fortunately, flickers and woodpeckers also nest in wooded areas where starlings rarely venture. Bluebirds, however, which nest only in tree cavities in relatively open fields and are no match for the starlings' boldness or numbers, have been severely depleted so that today they are a rarity over much of their former range.

Sheer number, as well as aggressiveness, is also an important factor in the starlings' successful colonization of an area. When a flicker gives chase to a starling, for example, another often slips into the vacant nesting hollow. Today the number of starlings far exceeds the available nest hollows; in early April

starlings can be seen poking their heads into virtually every dark crevice in trees and buildings.

As the first starling colonizers to the Middle Atlantic States began to feel population pressure from their own species, another mechanism, described by ornithologist Brina Kessel, now of the University of Alaska, worked to spread the flocks westward. The first- and second-year juveniles, which are not yet tied to a territory or to nesting routines, are forced into new, unoccupied areas. Attracted by late summer fruit crops or grain harvests, these adolescents first appear as marauding flocks. By the following spring, they molt and settle down to breed a new wave of offspring.

Thus, by 1918, less than thirty years after their introduction in New York City, the advance line of migrant juveniles extended from Ohio to Alabama; by 1926, from Illinois to Texas; by 1941, from Idaho to New Mexico; by 1946, to the California and Canadian coasts. M.T. Myres of the University of British Columbia reported that from 1954 to



A yellow-shafted flicker (far left) enters a tree cavity it has chosen for a nest site. A starling, also a cavity nester, zooms in on the flicker (center), knocks it aside, and takes over occupancy of the nest site (left). This eviction took place in New York's Central Park.

1958 a starling roost near Vancouver grew from 500 to 25,000 birds. European starlings were introduced in Hawaii, New Zealand, and Queensland, Australia; in eighty years they have virtually circled the globe back to the Old World.

In the United States, the automobile age proved a boon to starlings. When the use of cars made the suburbs accessible to migrating urbanites, starlings, which shun high grass as well as woods, were provided with replicas of their Old World foraging grounds—the close-cropped pastures of England and the Continent. The power mower did the work of sheep, providing the starlings with lawns abundant in seeds, insects, worms, and grubs.

The superhighways that cover the American landscape have also enlarged the starlings' foraging area with thousands of miles of wide, grassy shoulders and median strips. In addition to the bountiful harvest that they glean from the edges of roads, starlings add to their diet by dashing out into traffic lanes to snatch insects killed by cars.

Municipal dumps, another aspect of our energy-intensive life-style, have also boosted starling populations. Unlike their Old World preautomobile ancestors, which burned up energy combing large areas for thinly dispersed seeds and insects, contemporary starlings need only locate the nearest of these huge feeding stations to meet their nutritional requirements. Unperturbed by the clanking of unloading trucks or the roar of bulldozers, they can pick among a variety of foods unavailable to their ancestors.

The mechanization of agriculture has provided another food source for the omnivorous starlings. Like domestic cattle or poultry, the birds need only wait for the feed truck to arrive. They swoop down and feed on the grain provided for cows, pigs, chickens, and turkeys in large, open feedlots, supplementing their diet in summer with worms and flies found in concentrations of animal waste.

Much of the starling's success in the New World can be attributed to its ability to blend in, almost unseen and unheard, with our postwar "good life." The behavior, color, and song of starlings fit so subtly into everyday life, that many people are unaware of being in ecological league with this aggrandizing bird and are often unable to recognize it.

Starlings often escape specific notice because they are confused with the more conspicuous grackles, which are larger, sleeker, and have longer tails and black beaks; or with cowbirds, which are smaller, more sparrow-shaped birds with dark, blunt beaks. The starling is the size of a red-winged blackbird, has a long beak, which narrows toward the tip, and a short, stumpy tail. It is most frequently found waddling with others on lawns and mowed highway shoulders. In its front-heavy flight, it presents a triangular outline: the spiked beak forward, wings steadily whirring, lacking the fancy lilt or bob of the longer-tailed blackbirds. For birds that live near man, they are quite wary and can rarely be approached on foot; by car, however, one can come near enough to make out the iridescent purple sheen of their black feathers.





At sunset, a flock of starlings swarms toward a communal roost in a grove of trees. In the country, the birds prefer farm areas where food is plentiful.

In winter, starlings frequently perch motionlessly in treetops, their dark plumage difficult to distinguish among the bare branches. Their most common call is a high, sharply descending whistle that sounds like an unoiled wheel of a shopping cart. Although they are able to imitate other birds and even parrot a few words when kept in captivity, their calls are generally unmusical. For the most part, their vocalizations blend with the backdrop of mechanical noises of city and suburb.

During the winter months in nearly every American city where the temperature drops below freezing at night, starlings swarm in from the suburbs to form large communal roosts on building ledges, under bridges, and in park trees. The accouterments of city living-a few extra degrees of warmth, wind protection, and dry, snow-free perches provided by urban buildings-can carry a flock of starlings through severe blizzards that can decimate bird populations in the open countryside. On very cold days, starlings often perch on roofs near chimney openings, and John Kieran, in A Natural History of New York City. reports them roosting in the billboard structures of Times Square, basking in the warmth emitted by thousands of light bulbs.

City roosting, even in the Old World, is a relatively contemporary phenomenon. Only a century ago, according to British ornithologist

Two pugnacious birds, a blue jay and a starling, come face-to-face near a bird feeder. Both species benefit from association with man. G.R. Potts, starlings were rare visitors to English cities, where now they have established hundreds of roosts. In Bradford, six million birds have been counted. As the industrial revolution built up steam so did starling populations, taking advantage of heat emissions and the ornate architecture of the Victorian Eratypified by tall stone buildings with ornamental porticos and Corinthian columns-where they found drier and warmer shelter than anything nature designed. Examples of this architectural style in New York City, such as the Municipal Building and the Surrogate's Court on the borders of City Hall Park, accommodate thousands of starlings in what may be the oldest roosts in this country.

The architecture of today's elevated expressways, overpasses, roadway ramps, and bridges now provides drier shelter and more ample perching space than the birds had in Victorian times. Horizontal steel 1 beams, supporting wide slab roofs of cement, make excellent sleeping quarters protected from wind and rain.

Starling roosting patterns and suburban commuting routines have come together with an elegance normally associated with untold years of evolution. The outer limits of suburban sprawl make an ideal flight range for starlings—from roost to foraging grounds. Starlings, which may feed in the same general area for days, set out with the first light of morning and reach particular lawns or highway strips within a half hour. Thus, while the great mass of commuting workers stream into the city, starlings fan out into the bedroom suburbs; when the commuters return to the suburbs, starlings fly back into the cities for the evening.

Winter flocks, which are leaderless and may number from three to fifty or more birds, frequently split or join other flocks throughout the day until about an hour before dark, when they cease foraging, rise into trees, and increase the pitch of their calls. Then flock will join flock and, within minutes of the previous afternoon's departure, all head off in the direction of the city. At this moment the great spread of starlings over a suburban area begins to contract into assembly, or staging, points.

A good place to watch these assemblies is on top of the Palisades at Fort Lee, New Jersey, a few hundred yards north of the George Washington Bridge. Here the birds gather from suburbs to the west before making a final two-mile flight across the Hudson River to Manhattan. They crowd the rock ledges and trees at the cliff edge, creating a cacophony with the frenzy of their calls. Soon the birds make the flight over the Hudson River, some launching in unified explosions of wings, others in small flocks or flying singly, giving the general effect of a great black cloth ripping apart and shredding, and finally come to roost under the two bridges that span the Harlem River in the vicinity of 181st Street.

Only a relatively small proportion of starlings in the United States and Europe roost in cities; others commonly seek out thick pine groves, frequently around reservoirs or private estates. Urban roosts, however, are the more dramatic, especially when the entire flight is viewed as it passes over a city skyline. During winter sunsets in Rome, one can watch long strands of starlings merge from different directions, swoop upward over the church cupolas, and suddenly plummet to their roosts.

What is so striking about New York's starlings is that in a square half-mile of intersecting traffic arteries over the Harlem River-marked by a jumble of cement ramps, elevated cloverleafs, concrete columns, and a canopy of steel struts and girders-the birds have discovered an area with fewer humans afoot than any within miles of the city. The constant traffic from the Major Deegan Expressway, Harlem River Drive, Cross-Bronx Expressway, and the twelve-lane superhighway from the George Washington Bridge has driven away pedestrians and turned the area into a sanctuary for birds able to tolerate engine noise and exhaust fumes.

On the east side of the Harlem River, where most of the birds roost, speeding trucks, cars, and commuter trains make access by foot highly risky. Among the few people to enter the area are bridge painters. According to contractor Joseph Jacinto of Dynamic Painting, in 1973 his men

had to use cold chisels and hammers to crack off eighteen-inch-thick, hardened cakes of guano that had accumulated on beams and gusset plates. Each morning the painters would return to find their scaffolding and freshly applied primer coated with droppings.

From about mid-October to mid-March, when the ranks of birds that breed locally are probably doubled by those that breed to the north and Canada, the roost numbers from a quarter- to a half-million starlings. The starlings do not seem to be bothered by the mechanized racket or clouds of exhaust that billow into their roost from the roadway ramps below. The most popular perches, in fact, are directly under the roadbed of the 181st Street Bridge where, only a few inches above the birds' heads, truck wheels hit potholes and set the entire bridge rattling. Here the birds are out of the wind and do not catch the droppings of other birds.

In heavily populated areas such great concentrations of birds cannot go unnoticed indefinitely, especially when they interfere with man's technological life-style or when their presence offends the sensibilities of their human neighbors.

On October 6, 1960, at 5:40 P.M., a Baltimore-bound Electra lifted from a runway of Boston's Logan Airport, went into a sharp left turn, and plunged into Boston Harbor, killing sixty-two passengers. Although this turboprop plane was reputedly accident prone, the airport managers suggested that the crash might have been caused by starlings. A nearby garbage dump supported large numbers of starlings, the crash occurred at roosting time, and with their tolerance for loud noises, starlings were unlikely to flee from an approaching jet. After a hundred or so dead starlings were found on the runway, federal aviation experts conducted an experiment in which live starlings were sucked into an Electra engine. They discovered that bits of the birds, chopped up by the propellers, disturbed the delicate balance of air flow in the engine. Meanwhile, the engines of the downed plane were hoisted out of the harbor and found to be clogged with starling feathers and flesh.

The accident gave rise to numerous dispersal and extermination schemes. The British, who during the 1960s had to delay flights from some airports at roosting time, tried with great effort to scatter starling flocks. Wrote T. Brough in the British Journal of Applied Ecology:

"It is rarely possible to decide in advance how much effort is required to disperse a roost and the surest way for quick results is probably to use all the means available. Consequently, few roost dispersals are carried out without the accompaniment of one or more of the following noise effects: shooting, handelapping, shouting, football rattles, tin or dustbin lid banging and explosions from automatic acetylene bangers and rope cartridges. It should be emphasized that rarely will any of these measures, including shooting, produce any significant dispersal effect when used alone."

Brough goes on to explain his "bioacoustic" method, in which a starling's taped "distress call" is broadcast over loudspeakers at a roost. If broadcast early in the roosting season over many evenings, the distress call will keep the birds from landing, but if introduced too late or into well-established roosts, the piercing sound, like that of a drill on metal, has no more effect on starlings than the sound of truck motors or jet engines. Furthermore, as starling tolerance of the call increases, human tolerance reaches a breaking point. Like similar noisemaking inventions-including recorded eagle screams and propane gas cannons that fire at unexpected moments-the distress call can be used only sparingly at city or suburban roosts. A company that makes expensive loudspeaker systems for fruit growers warns that prolonged exposure to the call can be injurious to human hearing.

Other humane but ineffective techniques to reduce or disperse starling flocks include a birth control agent, or gametocide, called triethylenemelamine, which when fed to adult blackbirds during the breeding season, will reduce hatchlings by 20 percent; but no one has come up with a way of administering it exclusively to starlings. Heated roosting houses placed in remote

urban areas have failed to entice starlings away from buildings or parks. Mirror-studded plaster of Paris cats, stuffed owls, and rubber snakes set up on roosting ledges were quickly turned into perches by the birds. Electrified wires and sharp metal spikes placed on the ledges of many governmental buildings have proved effective, but they are costly, as well as unsightly. A sticky jelly smeared on ledges is supposed to give the birds an unpleasant landing and a chemical hotfoot, but it loses strength as layers of city soot accumulate. One man even designed an owl that periodically flipped up and hooted.

These methods of dispersing the birds only put off the problem and, in some cases, may make it worse by driving the birds to new roosts where they become more of a nuisance. Killing starlings, on the other hand, may stir opposition as illustrated by the experience of Waterbury, Connecticut, officials. A roost of some quarter-million starlings had built up over a three-year period in the courtyard trees outside the city hall. Commuters leaving the courtyard at sundown had to use their windshield wipers when they stopped for traffic lights. Sidewalks, made slippery by droppings, had to be sanded daily, and a smell hung in the air. Mayor Victor A. Mambruno appointed an aide to rid the city of the pests, but stuffed owls, distress calls, and searchlights trained on the trees all failed. With complaints from office workers increasing and the possibility that wind-borne dust from starling droppings can cause histoplasmosis, a tuberculosislike disease, the aide called a police raid. Early one December morning, twelve officers with shotguns stood under the roost trees and fired at clusters of the shadowy silhouettes, but before they could reload, the flock took off, leaving only 2.000 starlings dead.

A few citizens came to the defense of the starlings, but most of those who did also expressed understanding for the city officials. Edmond Tofeldt, general manger of the Connecticut Humane Society, was quoted in the *New York Times*: "We would have protested the shooting if we had known about it in advance,

but it came up suddenly. It would have been all right if they had killed them outright, but light birdshot leaves a lot of cripples, and that's cruel. They've certainly got their problems.

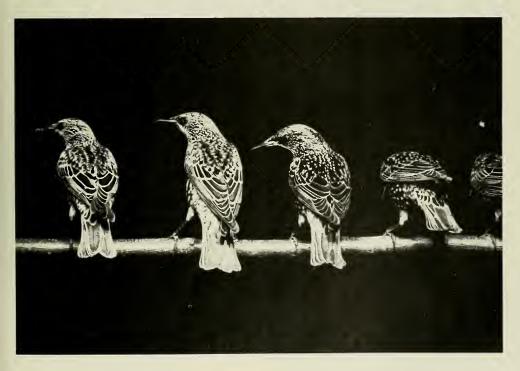
A more practical, low-profile method for killing starlings, known as the "Syracuse Program," was worked out by Benjamin P. Burtt, a chemist at Syracuse University. Large coop traps, 24 by 50 by 7 feet, made of chicken wire and baited with food and decoy starlings, were placed out of public sight on rooftops near a large starling roost in downtown Syracuse, New York. The birds entered the traps from the outside by alighting on the wire, folding their wings, and squeezing through tight, funnellike openings. When attempting to leave through the same holes, however, the birds found no perch, and with their wings outspread and fanning, they could not escape. During the winter of 1963-64 the traps captured up to 2,000 birds a day. These were then gassed and disposed of.

The most efficient, though highly controversial, method of killing the birds uses Tergitol, a chemical detergent. When sprayed on starlings, Tergitol dissolves the oil on their feathers and causes their death by exposure. But even this method is not foolproof. Tergitol spraying must be done in conjunction with both rainfall and a temperature below 45 degrees Fahrenheit. Last February, the town of Greenbriar, Tennessee, hired commercial duster planes to spray Tergitol on its starling roost and succeeded in wiping out 90 percent of the birds.

No matter how much starlings are persecuted, however, their successful colonization of the New World seems assured. They have adapted to the American life-style as no native birds have-thriving on the effluvia of an automobile-loving, lawnproud, energy-wasteful culture. Unlike more specialized birds such as the osprey or the bluebird, starlings have numerous ecological options for survival. They can perch equally well on the round twigs of trees or on the flat ledges of city buildings; their all-purpose beaks can drill for grubs in lawns, crack seeds, pry open French-fried potato bags at McDonald's parking lots, or as happened in England, eat putty from sixteen panes of a freshly glazed greenhouse.

Starlings, in fact, have become so locked into the Western way of living that they serve as a useful omen of how far that culture is out of whack with nature. As technological societies become more and more addicted to chemical fertilizers and beefsteak, automobiles and suburban sprawl, the number of animals that can tolerate the resultant environmental changes is narrowing down to a few opportunistic species, such as the starling, equipped to multiply on human wastefulness.

Starlings use a wide variety of objects as perches. They seem equally comfortable perching on a branch or a building ledge.



First Prize

The Natural World

Monument Valley, Arizona

Stephen M. Bull

The Perceptive Eye

A Portfolio of the Prizewinning Photographs from the 1975 Natural History Magazine Color Photography Competition

Years ago, when photographic equipment was cumbersome and each shot required elaborate preparation, photography was a specialized profession, practiced by few. But technological advances have revolutionized photography: there are now some 80 million cameras in use and even the incipient amateur can produce a correctly exposed, sharp picture.

This very accessibility to the craft is what made judging the 1975 Natural History photo competition difficult. Few pictures were eliminated for technical reasons; overwhelmingly, the photographs revealed expert use of sophisticated equipment. But this is also what made the contest exciting. Not satisfied with pictures that were merely of excellent technical quality, the judges looked for other, more subjective characteristics, evidence of visual imagination and

involvement. Their choices for the fourteen prizewinners, selected from nearly 4,000 entries, reveal the harmonious marriage of technique and interpretation.

The categories for the competition—The Natural World, A Chronological Sequence of an Event in Nature, and Humor-encouraged a diversity of subjects, perspectives, and feelings. Certain subjects—the sequence of a showering gorilla taken by Robert Scales; Mary Sue Ubben's shot of a photographer with a bird on his head—are inherently photogenic. Similarly, certain spectacular events, such as the eruption of Fuego, clearly invite photographing. Bruce Hunter, a graduate student in geology, was on a field project in Guatemala when the eruption occurred last October. Not only did the event lead to his winning an Honorable Mention in the contest, it also changed the course of his research from mapping the mountain's flanks to studying the virgin ashfall and glowing deposits left on Fuego's slopes.

In these cases, good fortune combined with talent to create striking photographs. Photography, however, can also be a way of capturing the beauty of a seemingly ordinary subject. Some photographers display, as one of the judges put it, "the feat of seeing." They understand that the great picture is often the result, not of an unusual subject, but of







First Prize

A Chronological Sequence of an Event in Nature Herdsman with cow and calf; Langtang Valley, Nepal Amos S. Eno











Honorable Mention
Purple passion blossom
Andrew B. Wile

Honorable Mention

Green frog; Grand River, Michigan

Robert Carr



unusual perception. For these photographers, the art of picture taking is, in fact, the art of visualizing. Peter Ruof's photograph of a rainbow, first prizewinner Luis Villota's view of an Australian ram, Robert Carr's view of a green frog—certain subjects become special because of the photographer's perspective and interpretation.

Sometimes, the image is there, but the photographer has only a moment to capture it. Stephen Bull, who won First Prize in the Natural World category, was driving through Monument

Valley when he saw three wild horses galloping past a butte. Jumping from his car, he managed to photograph the last of the three. Then he swept away the tin cans and other litter that appear in the foreground of the picture and waited, his camera set, but no more horses appeared. Peter Kaplan, seeing a gull light on a piling, was immediately moved by the scene's starkness but was able to make only one exposure before the bird flew away.

Other beautiful photographs, however, are the result of much study, deliberation, intense

First Prize

Humor

Australian ram; Dubbo, New South Wales, Australia

Luis Villota



Overleaf

Grand Prize

San Francisco at dawn Ian C. Tait









Honorable Mention Costa Rican vine snake; Puerto Viejo River, Costa Rica Dale Lewis

Honorable Mention Gorilla; San Diego Zoo, California Robert Scales



involvement with the subject, and patience. Ian Tait, whose photograph of San Francisco at dawn won Grand Prize, described this process—in an Ansel Adams term—as "previsualizing" the picture he wanted. He set up his tripod, then waited half an hour on the slopes of Mount Tamalpais until the early morning light fit his concept. Andrew Wile, whose sequence of the bursting purple passion blossom won an Honorable Mention, studied the plant daily, fascinated by the texture of the leaves against the blossom.

By definition, a photograph is a still image and captures only a moment. Yet a perceptive photographer can expose far more than that moment. He can imply a past, suggest or evoke strong feelings about a subject, including his own relationship to it. Such qualities are evident in Amos Eno's series of the herdsman with the mother cow and her young. Taken in the Langtang Valley, Nepal, the photograph won First Prize in the Chronological Sequence category. Ironically, Eno was in the Langtang Valley to study the extent of habitat destruction and was taking photographs to document his report.

David Sorensen, too, conveys a whole constellation of feelings about the peasant he photographed at the market at Cuzco, Peru.

The category that proved most difficult to judge was Humor. It had the fewest entries, and of these, many were visually imaginative, but simply not







Honorable Mention

Volcanic eruption of Fuego;

Guatemala

Bruce E. Hunter







funny. Humor, an abstract, conceptual quality, is difficult to render in the literal art of photography.

Judges for the competition were Thomas Page, designer of *Natural History*; Arthur Rothstein, one-time photographer with the Farm Security Administration, now with *Parade* magazine; Everett Opie, a cartoonist with the *New Yorker*; and Arnold Drapkin, editor for color photography at *Time*.

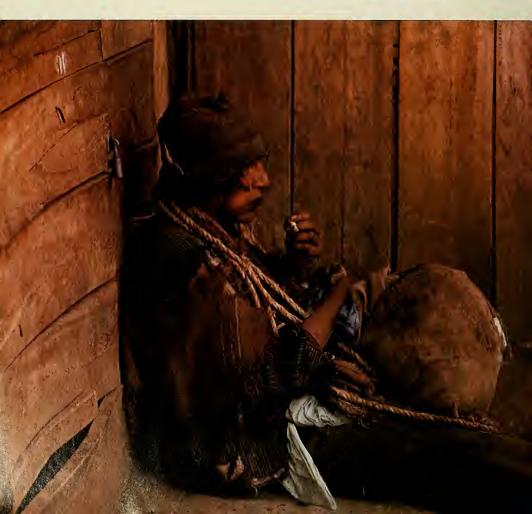
For their part, the prizewinners will receive the following: Grand Prize, round-trip to Rio de Janeiro and the Amazon Valley; First Prize in each of the three categories, \$250; Honorable Mention, \$100. For our part, we have the pleasure of enjoying their beautiful photographs and the joy of sharing, however vicariously, their photographic experiences.

The prizewinning photographs will be displayed at The American Museum of Natural History in the fall.

Toni Gerber

Honorable Mention
Rainbow and fence; Colorado
Peter C. Ruof

Honorable Mention Peasant at the market; Cuzco, Peru David Sorensen









Honorable Mention
Photographer with bird;
Mount McKinley National
Park, Alaska
Mary Sue Ubben

The Hundred-Year Hibernation of the Water

If it is too dry or too cold, this minuscule invertebrate suspends its life processes until better times return

Like some gifts, some fascinating natural species come in small packages. Tardigrades, microscopic invertebrates belonging to the phylum Tardigrada, range from only 100 microns to a millimeter (½, inch) in length. Yet they are intricately structured, play an important role in the food chain of various ecosystems, and may even provide an understanding of the aging process in all species, including humans.

Because of their four pairs of legs terminated with claws and their slow, lumbering movement, tardigrades are called bear animalcules or, more commonly, water bears. Goeze first observed a Kleiner Wasser Bar ("little water bear") in 1773; the Italian naturalist Lazzaro Spallanzani referred to the organism as il tardigrado ("slow stepper") in 1776. Since tardigrades were discovered about two hundred years ago, scientists have described more than four hundred marine, freshwater, and terrestrial species. From the Arctic to the Antarctic, from the slopes of the Himalayas to the depths of the oceans, these ubiquitous creatures inhabit a diversity of niches in sand, soil, mosses, lichens, liverworts, algae, and other specialized microenvironments. Many have a cosmopolitan distribution; others are endemic and rarely encountered.

The stocky body of a tardigrade is covered with a nonchitinous cuticle. In some species this is smooth and thin; others are ornamented with pigments, pores, papillae, or plates. Papillae, spines, and other filamentous structures on the body, including the appendages on the head, apparently have a tactile sensory function. The cuticle itself helps to slow evaporative water loss, a vital function in an organism that is subject to periodic desiccation.

Tardigrades, even in similar habi-

tats, exhibit a variety of colors—white, pink, purple, green, red, yellow, and gray. The color is determined by the contents of the intestine (the type of food ingested), free globules and granules suspended in the fluid of the body cavity (which may function as stored fat bodies), or pigmentation of the cuticle itself.

As a link in the food chain, tardigrades occupy a specialized niche in the marine, freshwater, or terrestrial ecosystems they inhabit. With a feeding apparatus that consists of a mouth tube, a muscular, bulbous pharynx, and a pair of piercing stylets, they are well adapted for puncturing the cell walls of plants or the bodies of other animals and sucking out the contents.

Marine tardigrades consist of interstitial species that live between sand grains, epizoic species that live on algae and vegetational debris on surface sediments, and species that live on or in other marine invertebrates. There are also deep-sea tardigrades, but these are relatively rare.

Competition for food is not intense because of the abundance of many kinds of food organisms, Although the specific foods of the marine tardigrade species have not been identified, differences in the



All photographs by Robert Schuster

Bear

structure of the feeding apparatus and in the color of the liquid food material in the gut indicate differences in the manner of feeding and, thus, in food selection. Batillipes, for example, has stout stylets with accessory supports and is capable of making short powerful thrusts, while Stygarctus, which inhabits the same environment, has long, thin, unsupported stylets, which can be extruded up to half its length.

Some tardigrades live in intimate association with other organisms in what is either a parasitic or comensal relationship. By inhabiting such specialized environments as the

algae that grow on intertidal barnacles, the mantle cavity of mussels, the tentacles of a sea cucumber, and the pleopods of the isopod *Limnoria lignorum*, these tardigrades obtain not only food but also shelter and transportation from the host.

Freshwater tardigrades inhabit aquatic mosses, algae, rooted and aquatic vegetation, mud, and debris in puddles, ponds, lakes, rivers, and streams. They live primarily on algae, protozoans, organic detritus, and the cell contents of submerged mosses.

Terrestrial tardigrades share their environment-mosses, lichens, liverworts, soil, and leaf litter-with a diversity of other organisms, primarily rotifers and nematodes, but also bacteria, protozoans, mites, and small insect larvae. Food is seldom a limiting factor since most tardigrades feed on algae, organic detritus, bacteria, and plant cells, all of which are present in great abundance. Some large species of tardigrades are predacious, feeding on protozoans, rotifers, nematodes, and even other tardigrades. While our knowledge of feeding habits and the subsequent effect on species distribution is incomplete, it seems that certain factors—an excess of organic debris, predators (nematodes, mites, spiders, larval insects, and other tardigrades), and parasites (sporozoans, fungi)-selectively influence presence of certain species.

The key to survival of all species is, of course, reproduction. In tardigrades the sexes are separate. Individuals have either male or female reproductive organs, but in some genera, such as *Echiniscus*, there are

Magnified 1,600 times under a scanning electron microscope, a tardigrade. Echiniscus maucci, resembles a prehistoric monster. Its pore-covered cuticle helps retard water loss by evaporation.

no males and the females reproduce parthenogenetically.

Sexual reproduction also occurs. In some freshwater species, males deposit sperm in the old cuticle of the female just before molting, and fertilization occurs when the eggs are also deposited into the old cuticle, just as it is separating from the new one. Terrestrial species fertilize their eggs internally, with the males injecting sperm either into the genital cloaca or through the cuticle into the hemocoel. Eggs, however fertilized, may be laid singly, in groups attached to the substrate, or in the molted cuticle.

In some species the eggs develop various types of projections that may protect them from predators. Also, by increasing the surface area of the egg, such projections may enhance gas exchange (oxygen and carbon dioxide) between the developing embryo and its environment. Similarly, some eggs are covered with pores, which possibly also function in gas exchange. Development is direct, and after two weeks the young tardigrade hatches from the egg by rupturing the shell with its stylets. After the second or third molt, which occurs within a few weeks or a month, the individual is sexually mature, and egg production continues through life.

By far the most interesting aspect of the tardigrade's life cycle is its capacity to "return to life" after extended periods of desiccation. First observed by Leeuwenhoek, the phenomenon of cryptobiosis, or "hidden life," which occurs in terrestrial tardigrades as well as in some rotifers and nematodes, enables these organisms to withstand the periodic drying that occurs naturally in their environment. Activity stops when the weather is dry and resumes when moisture is again present. Since the animal ceases to age during the cryptobiotic state, knowledge of the mechanism involved may provide clues to the aging process common to other organisms, including humans.

Cryptobiosis, formerly called anabiosis ("return to life"), is more a state of suspended animation than resurrection. Through an alternation of active and cryptobiotic periods, the tardigrade's life-span can be extended from less than a year to more than one hundred years. A museum specimen of dried moss that was 120 years old yielded active tardigrades when moistened. Not only desiccation but also other kinds of harsh environmental conditions can be tolerated in the cryptobiotic state. Cryptobiotic tardigrades, for example, can withstand extreme temperatures (300 degrees Fahrenheit to .008 degrees Kelvin, the brink of absolute zero), high vacuum, and ionizing radiations. For humans the lethal dose for 50 percent of the population (LD50) equals 500 roentgens; for tardigrades, 570,000 roentgens. Future space travel may utilize such principles to transfer life to other planets or even other solar systems.

Cryptobiosis normally occurs in response to daily or seasonal weather changes, or it can be induced in the laboratory. Exposed to drying conditions, the tardigrade begins to lose the water that makes up 85 percent of its body weight, until water makes up only 3 percent of its body weight. As movement ceases and contraction occurs, the animal assumes a barrellike shape ("tun") that decreases the rate of evaporation. Rapid water loss, which does not usually occur in nature, induces death from desiccation damage, perhaps by preventing synthesis of a unique protective molecule, possibly a carbohydrate, but as yet unidentified. But if the organism dries slowly, it can be revived by the addition of moisture. Tardigrades may also enter cryptobiosis when the temperature drops below freezing, when bacterial decomposition of organic debris causes low oxygen concentration, or in the laboratory when exposed to external solutions with high osmotic pressures.

What happens during cryptobiosis? Practically nothing. Metabolism, the primary characteristic of living things, is almost imperceptible and may cease altogether under some conditions, such as an oxygen-deficient environment. Although oxygen



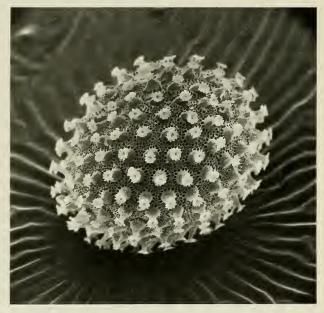
uptake occurs even under very low levels of relative humidity, recent laboratory evidence indicates that oxygen may not be essential to the survival of the cryptobiotes and may, in fact, be harmful. Cryptobiotic tardigrades maintained in an oxygen-free environment survive longer than those kept in oxygen, but we do not know how oxygen harms the inactive animals. The production of highly reactive molecular fragments called free radicals appears to be involved. Free radicals produced by the cells' own oxidative reactions may cause cross-linkage of large,

important molecules or even loss or change in the genetic information of cells. Aging and death may be due to the accumulation of free radicals and their products.

If organisms are considered dead when metabolism ceases, then do tardigrades actually "return to life"? Perhaps we need to redefine life and death in terms of structural integrity rather than the presence or absence of metabolism alone. Exposure to extremes of temperature and pressure, ionizing radiation, and chemicals are conditions that destroy organized structure in most organisms:



Because of their claws and slow, lumbering movement, tardigrades, left (magnified 2,400 times), are commonly called water bears. The eggs of some species, such as Macrobiotus hibiscus, below (magnified 1,200 times), develop projections, which may protect them from predators or, by increasing the surface area, enhance gas exchange between the embryo and its environment.



freezing ruptures cell membranes; heat and chemicals destroy enzymes and other proteins; radiation results in the formation of ions and free radicals, which damage tissue and cause death. Yet, for unknown reasons, these conditions are ineffective against the cryptobiotic state. Generally, degradative reactions require water, oxygen, and heat, at least one of which is usually absent in cryptobiosis.

In addition to prolonging life, cryptobiosis undoubtedly plays an integral role in the distribution of tardigrades over the world. This phenomenon enables the organisms to disperse easily and to live in a diversity of habitats, even those with minimal moisture. Dissemination of cryptobiotic forms occurs primarily by wind action, but rainwater, currents, waves, and other organisms, such as insects, also distribute cryptobiotic individuals as well as active tardigrades and their eggs.

Although tardigrades differ in their ecological requirements and their tolerances to variation in environmental factors, the specific needs of individual species have not yet been delineated. Moisture, oxygen, light, nutrient availability, feeding habits, and associations with other species may all prove significant as environmental regulators of distribution. Urban pollution may also affect tardigrades and may be the reason they are found more frequently in rural areas.

What we do not know about the life cycle of this minute animalcule, including those aspects that may provide clues to life itself and the aging process in all species, makes the water bear a fascinating subject to study. Like the unconquered mountain, the challenge remains.

Hard Times Along the Kuskokwim

by Lynn D. Mason

In "Alaska's ghetto,"
Eskimo live with the
deep wounds and pain of
past encroachments

The Kuskowagamiut Eskimo once were a thriving population of selfsufficient salmon fishermen, hunters, and trappers. Now they are struggling to retain their identity and regain their health on the cultural and geographical margins of the dominant American society.

Numbering more than 6,000, the Kuskowagamiut inhabit some twenty villages along the eastern edge of a 25,000-square-mile expanse of tundra, lakes, meandering watercourses, and inland foothills in southwest Alaska bounded by the Yukon and Kuskokwim rivers and the Bering Sea coast. Like that of other aboriginal American societies. Kuskowagamiut life-style and livelihood have undergone considerable changes since the arrival of European and American traders, teachers, missionaries, government officials, and other outsiders.

On the surface, Kuskowagamiut communities today are filled with the sights and sounds of the twentiethcentury northern frontier: log cabins, western clothing, outboard engines, chain saws, snowmobiles, electricity, and radios tuned to country and western music. Although many villagers continue to fish, hunt, and trap, most families are dependent upon a steady cash income for the purchase of goods and services. Men commonly seek seasonal employment in canneries, on barges, construction projects, and as fire fighters. A few obtain more permanent positions in stores, post offices. and schools.

Initial impressions of progress, however, are deceptive. Many villagers live in crowded, dimly lit, and improperly ventilated houses. In most places sewage disposal is inadequate. Clothing is often of poor quality and ill suited for protection against cold, rain, and wind. Diets are dominated by imported carbohydrates, and undernutrition is common during the winter months. Excessive drinking contributes to malnutrition, periodic violence, and numerous accidents. Full-time employment opportunities are scarce. seasonal wage labor is undependable, and local prices for many imported goods are exorbitant. Few men are able to purchase and maintain the tools they need to earn a satisfactory livelihood throughout the year. Chain saws, outboard engines, and snowmobiles often break down and are left to rust for lack of

The transition to modern life, then, has been neither smooth nor entirely voluntary. In their encounter with colonialism, the Kuskowagamiut have endured their share of religious intolerance, governmental pressure to adopt Western values and habits, bureaucratic paternalism, commercial exploitation, and perhaps worst of all, crippling infectious diseases. Smallpox, influenza, and tuberculosis, among others, have forced large numbers of disabled survivors into dependency relationships with state and federal agencies. For many, welfare has become a way of life. Officials and other observers have referred to the Yukon-Kuskokwim delta region as "Alaska's ghetto"; its Eskimo and Indian residents are among the poorest, least educated, and most disease burdened in the country.

The prevalence of disease and its debilitating effects, together with economic hardship, is the outcome of a century and a half of contact with Western culture. The spread of virulent diseases was an unforeseen but inevitable by-product of European expansion, which swiftly corroded the well-being of the Kuskowagamiut and dozens of other tribal peoples throughout the Americas, Oceania, and Africa.

Early in the Christian Era, the ancestors of the modern Kuskowagamiut separated from the maritime Eskimo on the seacoast and began migrating up the Kuskokwim drainage system. Their progress was accompanied by a shift in ecological dependency from sea mammals to riverine resources, primarily salmon, five species of which ascend the river between June and September. The population grew steadily, and new communities spread farther inland where they found an even greater diversity of food and fuel. There they could hunt and trap moose,. black bear, beaver, otter, and porcupine. Spruce, birch, and cottonwood provided fuel for heating and a workable medium for carving and constructing implements and facilities. Compared with other Eskimo habitats, the Kuskokwim basin was bountiful and secure.

> In late winter, when the usual food sources run low, women and children hunt ptarmigan, a grouselike bird common to tundra regions.

> > Robert W Stevens



The early Kuskowagamiut numbered between 4,000 and 5,000. Available evidence suggests that communicable diseases were rare or absent, and the primary causes of illness and death were bacillary dysentery, tapeworms, diseases of infancy, and accidents associated with economic activities.

When Russian explorers, traders, and missionaries ventured to the central Kuskokwim region sometime after 1825, they met an epidemio-

logically virgin population admirably suited to its habitat but immunologically defenseless against virulent disease organisms long endemic in European populations. Any material or spiritual benefits gained from the Russian settlers and transients were quickly offset by the introduction of smallpox. In the disastrous smallpox epidemic that spread from the Sitka area over much of western Alaska in 1838–39, approximately half of the Kuskowagamiut perished. Mor-

tality was especially high among those who had not been vaccinated by Russian officials. Survivors correctly blamed the Russians for the calamity, and one band of angry villagers responded by burning down a Russian trading post.

The most important social, economic, and religious changes in the lives of the Kuskowagamiut were initiated between 1885 and 1925 by a small group of Moravian missionaries who stationed themselves at the



Robert W Stevens

present site of Bethel. Aggressively dedicated, these Protestant proselytizers gradually persuaded many families in the area to abandon their animistic ceremonies in favor of the new faith. They were also successful in discouraging the continuation of the traditional institution of the men's lodge, which separated men from their families for long periods, thereby violating the Victorian ideal of nuclear family living.

The missionaries also encouraged

the growth of commercial interests, which led to cash payments for labor and resources. Imported foodstuffs and trade goods became necessities as increasing numbers of villagers adopted Western clothing, foods, house styles, and tools. More families were attracted to the larger settlements, where churches, trading posts, and schools were established.

These changes in life-style and demography were accompanied by steadily deteriorating health conditions. Small outbreaks of infectious disease were but ominous portents of the still-remembered "big sickness" of 1900–01, when the Kuskowagamiut were beset by successive waves of influenza, measles, and whooping cough, followed by a winter of famine. One-half the adults and all the infants along the river perished. Once endemic, these and other respiratory diseases took a heavy toll in periodic outbreaks as late as 1944.

Traditional medical practices were hopelessly inadequate for treating these major diseases. The success of the Moravians in converting many to Christianity followed in part from widespread loss of confidence in the community shamans, who were the Kuskowagamiut's religious leaders and most powerful curers. Many stricken villagers turned for help to the missionaries, one of whom was a doctor. Like epidemics elsewhere, those that struck the Eskimo killed the old gods along with the people and hastened the disintegration of traditional ways of life among the demoralized survivors.

The worst was yet to come, however. Generally poor health, crowded living quarters, lack of proper sanitation, malnutrition, fatigue associated with harvesting natural resources, and the absence of doctors paved the way for the "white plague"—tuberculosis—which was already prevalent before 1900. By World War II it was fatally victim-

Jigging for pike through the ice on rivers and lakes is a common wintertime activity. Like salmon, most of these fish are used for dog food.

izing Eskimo in southwestern Alaska at the rate of 1,000 per 100,000 population each year. Tuberculin sensitivity surveys revealed that close to 90 percent of five- to eight-year-old children in the Bethel area were infected.

Tuberculosis was truly epidemic and threatened the survival of the entire population. The disease was eventually contained after federal and state health agencies initiated a massive program of detection, hospitalization, and chemotherapy. Dozens of Kuskowagamiut adults joined hundreds of other Eskimo and Indians in hospitals and sanatoriums. By 1970 the tuberculosis death rate had dropped to zero, and among the Kuskowagamiut only a dozen new cases were discovered.

My introduction to the Kuskowagamiut and their health problems began in 1967 during a summer field study of salmon fishing and village economy. In 1969 I returned to the river and settled for ten months in Yugtalik (a fictitious name), a community in the subarctic transition zone between the coastal tundra and inland coniferous forest. Formerly a one-family fishing camp, Yugtalik emerged as a village when migrant families from several nearby localities permanently settled there. Village population grew from 88 in 1950 to 122 in 1960. Today there are 180 residents, living in some forty households on a fifty-acre site that includes two school buildings, a post office, a small sawmill, an electrical power plant, a town hall, and a small Russian Orthodox church. Most community members are closely interrelated by birth and marriage and there is much social interaction.

Both environmental resources and wage-earning opportunities are seasonal, thus affecting the livelihood of Yugtalik families. The men supplement fishing, wage labor, and welfare by trapping, hunting, wood gathering, berry picking, and craft sales. While they are earning wages, village men are prevented from harvesting fish and game, and vice versa, but these activities are not altogether mutually exclusive.

Income from all sources, including welfare, ranges from \$1,000 to \$9,000, but the average annual



Bruce Butzbach



Bruce Butzbach

Blueberries and blackberries, one of the few sources of vitamin C available to Eskimo, are usually picked by women and children. Berries are often eaten in a mixture of lard and sugar.

household income does not exceed \$3,500. It is still true, as one economist noted, that in the Kuskokwim region Eskimo exist in the greatest numbers, where, according to modern measures of compensation, they earn the least wages. Southwestern Alaska has failed to grow commercially, resulting in unemployment rates of from 45 percent during the summer to 90 percent during the winter.

Since job opportunities are erratic and inconsistent, wage-conscious Yugtalik men have adopted different strategies. A few men choose to go every summer to the canneries, where they can expect to receive about \$1,000 for a six-week shift. Others prefer to risk waiting for unpredictable but more lucrative firefighting jobs, which pay more than \$50 a day.

The Kuskowagamiut might have prospered with their traditional skills alone had they been spared the European's diseases. But they were not, and Eskimo life in Yugtalik and other villages along the river clearly bears the scars of a 150-year epidemic of excessive illness and debility. While I lived in Yugtalik, acute and chronic diseases disrupted the routine activities of most households one or more times. A stay in the Bethel hospital several times a year had become a routine activity for some. Dozens of others were treated in the village by either medical aides

The five salmon species that migrate up the Kuskokwim are dried and smoked for dog food. Eskimo eat smoked salmon only when no other food is available.

or by itinerant medical personnel.

Illness, like the weather, was a frequent topic of conversation, and an astonishing record of experiences with disease was revealed to me in the course of my study. Of primary interest to me were the economic consequences of disease and debilitation among the thirty-five village men who supported families or lived alone. Only five of these individuals had avoided major illness and hospitalization; the others had accumulated 330 hospital months between them, for an average of twelve months each. Annual X-ray surveys disclosed lung scarring in all of these men. Of seventeen who had been hospitalized specifically for tuberculosis, ten had undergone pulmonary surgery. From their testimony and from government health and welfare records, I concluded that fourteen of the thirty-five men were physically impaired to some extent in their activities, while seven others were severely handicapped.

Considering these health conditions in their economic setting, crippling disease has clearly been a significant factor in the changing culture of the Kuskowagamiut. The need for welfare is the most obvious indicator of changing livelihood. Since 1965 more than twenty-five Yugtalik households have received periodic or continual relief from the general assistance fund of the Bureau of Indian Affairs or from state programs such as Aid to the Disabled and Aid to Families with Dependent Children. Since 1970, thirteen of the disabled men have depended on some form of regular assistance, despite the fact that qualifying for Aid to the Disabled is a somewhat difficult and embarrassing procedure. Individual monthly grants are not generous and average only about \$150 per adult and \$100 per child, amounts that do not go very far considering the high cost of living in the area. In recent years, however, welfare grants have totaled more than 30 percent of the income in Yugtalik and other Kuskowagamiut settlements.

Successful fishing, hunting, trapping, and wood hauling often require prolonged exertion and endurance. Those with debilitating conditions usually cannot meet such demands without further endangering their

health. I could appreciate the tenuous position of many men like Alexie, a good-humored but often discouraged man of forty-five, whose difficulties began in 1954 when he entered a hospital with moderately advanced tuberculosis. He was married at the time and supported his small family by fishing, trapping, hunting, fire fighting, and cannery work. His condition was serious enough to warrant pulmonary surgery and fourteen months of bed rest, after which he returned to Yugtalik and \$100 a month in convalescent benefits.

A year later the Bureau of Indian Affairs welfare agency in Bethel, assuming that he was fully recuperated and able to work, informed him that aid was no longer necessary. Alexie, however, felt that he was no longer the same person. He says that he died during surgery, that part of his body was removed, and that another man's blood brought him back to life and now flowed through his veins. He found hunting, wood hauling, and trapping more arduous and time consuming. Unable to maintain his dog team while hospitalized, he could not afford to rebuild a team for several years and attempted instead to walk his traplines. He had little success and often found exposure to freezing temperatures unbearable. A further hindrance to his activities was a chronic eye problem that gradually impaired his vision.

By 1966, following letters of appeal written by himself, his wife, the village school teacher, and a Vista volunteer, Alexie had received half a dozen temporary relief grants from the Bureau of Indian Affairs. In 1967 Alexie fractured his leg in a snowmobile accident. Improper healing incapacitated him for nine months. and left him with, as he puts it, "bum legs." He could still fish satisfactorily and work in the canneries. but trapping became too onerous and he stopped trying. After 1968 Alexie applied twice to the state for assistance, but was turned down both times after examining physicians found no evidence of a disabling condition.

By 1970 Alexie had not fished in two years, had no inclination to trap, and declined to hunt during the fall and winter, despite his past reputation as a fine moose hunter. His movements were slow, his activities circumscribed. His attempts to make ends meet for his wife and four children were less than successful. Like others in similar circumstances, he drank heavily to relieve his boredom and frustration, which made him vulnerable to further pulmonary complications such as bronchiectasis.

Trapping in the Yugtalik area is a particularly good example of the adverse effects of physical disability on traditional skills. Formerly a popular and economically viable enterprise, trapping has declined due to decreased market values for furs, the availability of winter unemployment benefits, and a high incidence of disabling conditions among older, more traditionally oriented men. The returns in cash sales are not generous for the amount of time invested.

The economic difficulties of

Little Russian Mission, dominated by the church built in the 1950s, is one of many Eskimo settlements along the Kuskokwim. Village populations often fluctuate as job locations shift. Alexie and other Yugtalik men suggest not only a diminished self-sufficiency in general but a loss of cold weather productivity in particular. Climatic conditions in the Yugtalik area are influenced by both maritime and continental factors. During most of the year, the proximity of the Bering Sea modifies average daily temperatures, yet many periods in the summer and winter are dominated by hot and cold continental air originating from the Alaska Range.

Winters are characterized by temperatures as low as -50° F., moderate snowfall, and occasional blizzards. Like most villages in the delta region, Yugtalik and its environs are exposed periodically to strong maritime winds, which sometimes sweep across the landscape in excess of fifty miles per hour. During the winter such winds subject living things to dangerously low chill factors, and frostbite is common.

The physical and mental hardships of life in northern regions are well documented, and Eskimo are especially admired for their ability to work effectively in extremely cold temperatures. Many observers have concluded that Eskimo possess an inherited tolerance for cold. While laboratory studies have revealed differential responses to cooling among representatives of different races, the

evidence points to physiological acclimatization processes rather than to clear-cut genetic variability. Eskimo technology, especially clothing and shelter, have partially negated the selective pressures of a cold climate.

I became fully aware of the detrimental effects of disease on cold weather activities only after winter had descended and various men complained of discomfort when out of doors for more than short periods of time. Admittedly, griping about the weather was common in almost everyone's social conversation, yet invariably, those who complained most were those hampered by poor health and lingering infirmities.

For the average American, normal work is, in most respects, quite different from the daily rigors of subsisting in isolated subarctic regions hundreds of miles from urban conveniences. Most Eskimo returning from hospitals have not been rehabilitated in the sense of being restored to good mental health and useful activity through counseling, physical therapy, and vocational guidance. For most the hospital is an alien setting, in which participation in educational, therapeutic, or even recreational programs is uncomfortably difficult. Recuperating Eskimo return to the same conditions and opportunities that existed before



their confinement and, in most cases, are expected to readjust to those conditions with little or no change in life-style.

Under these circumstances, cold stress, overexertion, and fatigue are unavoidable. Yet villagers cannot afford to become physically inactive. Welfare payments and seasonal wages are barely adequate to cover basic necessities for most families beset by ill health. A monthly income of \$300 does not go very far when goods at the local trading establishment are priced 50 to 100 percent higher than the same items in Seattle. In Yugtalik and elsewhere, even the handicapped periodically must engage in strenuous activities, such as salmon fishing, wood hauling, and hunting.

Official recognition of hardships faced by chronically disabled villagers is not widespread among state and federal agencies. In many cases government assistance is not only insufficient but of temporary duration; not infrequently, it is accompanied by humiliating failure to prove real need. In general, the Bureau of Indian Affairs, U.S. Public Health Service, and Alaska Department of Health and Welfare are openly responsive to periodic needs caused by illness. But when individuals who perceive themselves

unfit for normal work apply for long-term benefits, difficulties and misunderstandings often arise. In many instances the expectations and demands of some welfare agents and physicians appear to be unrealistic and ethnocentric.

Not surprisingly, anger and resentment are often expressed by those who honestly feel they deserve financial aid but are turned down. Some feel particularly frustrated because two or more physicians have conflicting opinions. One Yugtalik man, for instance, was called hypertensive by one examiner who recommended assistance but hypochondriac by another who recommended no assistance. His eligibility has yet to be determined.

Although some Public Health Service doctors are well respected, especially those who stay in the area for awhile and acquaint themselves with the villagers, others are felt to be too aloof and isolated from village life to understand the people's problems in proper context.

The future holds many uncertainties for the Kuskowagamiut. The spread of new diseases, the eventual acceptance of Western therapy, and the prevalence of disabilities among survivors have combined with other modernizing trends to discourage traditional modes of environmental

exploitation and to push households further into the orbit of the market economy with its dependence on cash resources. With the advent of electricity, snowmobiles, plumbing, and other technological innovations. material aspirations have far exceeded purchasing power. Pressured to share in the material advantages of the industrial state while living in an economically depressed, nonindustrialized region, most households have little prospect for affording more than the basic materials necessary to exist at a minimum level of comfort and security.

As the Kuskowagamiut continue to move away from traditional modes of livelihood, more and more of them-the able-bodied and disabled alike-are introduced to contrasting life-styles-in college, job corps, vocational training, and the armed services. The modern alternatives presented by a rapidly changing world make the old skills, related to extracting a living from the land and water, less attractive and more toilsome. If the Kuskowagamuit ever become fully modernized and cease to hunt and fish out of necessity, they will long remember the white man's plagues, which came from the "outside" to their homeland, disrupting and changing their lives in fundamental ways.



Sloth Droppings

by Paul S. Martin

About 11,000 years ago, the Shasta ground sloth suddenly disappeared. Clues to what caused its extinction may be found in the dung it left behind.

The climb up the steep talus slopes was exhausting. I catch my breath at the gate blocking the entrance to Rampart Cave in northern Arizona. Five hundred feet below, the Colorado River flows through a gap in Grand Wash Cliffs, leaving Grand Canyon and entering Lake Mead.

The National Park Service guides unlock the gate for me and, after briefly inspecting the cave's contents, they return by boat down the lake to the Temple Bar Ranger Station. I watch the winter sun drop behind sheer walls. To the northwest, a growing cloud bank portends a rapid change in weather. Dark shapes emerge from the tamarisk thickets along the Colorado River. Austin Long and six of our students from the University of Arizona are backpacking in from the Pierce ferry landing to join me at the cave. I watch as they thread their way upslope between huge blocks of detached Muav limestone left behind by an ancient mudflow.

Inside the gate is one of the most remarkable fossil deposits in the world. Its value can only be compared with such other paleontological treasures as fossil insects preserved in amber or the frozen mammoths of Siberia. The cave mouth leads into a 40- by 50-foot chamber, the floor of which is covered with something even more remarkable than fossil bones. Rampart Cave, one of only nine such cave sites known, holds the biggest and bestpreserved deposit of ground sloth dung (and I've seen them all) in the world.

Trenches dug in the deposit by earlier paleontologists exceed four feet in depth. Twigs mixed with the fecal pellets of pack rats are sandwiched between layers of sloth dung. The twigs and other plant material were brought into the cave by pack rats over a period of thousands of years. Beneath vaults in the ceiling lie thin layers of free-tailed bat guano. Scattered bones—of a ground sloth, an extinct yellow-bellied marmot, a Harrington's mountain goat, or a pack rat-and even sloth hair can be found in the layers exposed by previous research excavations. But most of the deposit, nearly 200 cubic yards, is composed of dung of the extinct Shasta ground sloth (Nothrotheriops shastense). Untrampled lumps in corners are the size of softballs. Identification is all but certain. No other animal in Arizona, extinct or living, is known with dung of this size and texture.

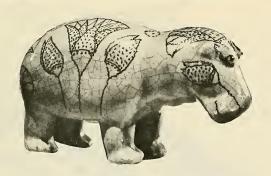
The dung looks and smells fresh, as though recently dropped. The

carbon-nitrogen ratio on the surface of the dung is similar to that of cow manure, further evidence of the quality of preservation. The ancient fecal remains still contain much water-soluble material reminiscent—in color and odor—of a barnyard drain.

The first cave found to contain ground sloth dung-along with hair and even a large piece of hide-was discovered, not in North America. but in the southern tip of South America. At the turn of the century, travelers and scientists converged on a large cave near Ultima Esperanza Sound in southern Chile. The perishable remains in the cave led the Argentine paleontologist Carlos Ameghino to describe what he believed was a new species of ground sloth and to predict that living ground sloths would be found in the region. A London newspaper financed an expedition to search for







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Droppings of the extinct Shasta ground sloth line the bottom of Rampart Cave, Arizona. Although 11,000 years old, the odor and appearance seem fresh.

living ground sloths. The scientific world was ablaze with curiosity. The dung balls of the South American sloths were larger than those of circus elephants!

But no living ground sloths were reported. Another thirty years passed before caves containing sloth dung were discovered in North America. And no ground sloth remains have emerged from geologic deposits of the last 10,000 years. For these reasons, paleontologists have discounted any romantic notions of a late survival, such as the possible persistence of living ground sloths in some remote corner of South America or at the bottom of the Grand Canyon.

Four genera of ground sloths lived in North America during the late Pleistocene, and twice as many genera inhabited South America. Their living relatives, the tree sloths, are diminutive and more highly specialized. Ground sloths may not have been quite as languid and slow moving as their contemporary arboreal relatives, but their stubby, arthritic-looking bones and long, unretractable claws must have made it impossible for them to move quickly. They would have had to endure the attacks



Gene Gotten

of predators while standing their ground. Their anatomy suggests that while some species were browsers, no ground sloth climbed trees.

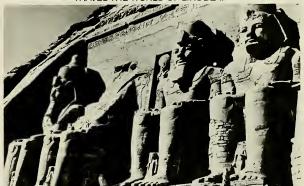
The largest of the extinct genera, Megatherium, apparently was larger than an elephant. The shearing molar cusps of these monstrous terrestrial animals suggest that they were superbly adapted browsers. In the rich tar bed fauna of Talara, Peru, for example, Rufus Churcher of the Royal Ontario Museum discovered sheared twigs that fit the occluding cusps of Megatherium teeth from that deposit. Radiocarbon dating of the twigs revealed that they were 14,500 years old.

Another peculiar group of ground sloths, the mylodonts, were almost rhinocerous sized and possessed a dermal armor formed of closely spaced, peanut-sized bones embedded in their thick hides. Even if other bones are lacking, the presence of the distinctive dermal bones is diagnostic of the presence of mylodont sloths in a fossil fauna.

The largest surviving piece of ground sloth hide, found in the Ultima Esperanza Cave, is on display in the Museo de la Plata, Argentina. It is almost three feet in diameter, partly folded, with patches of hair remaining. The embedded dermal bones establish its identity as a mylodont. Radiocarbon dates recently obtained from this prize specimen show that, despite its appearance, it is quite old. The radiocarbon dating method indicates that those in search



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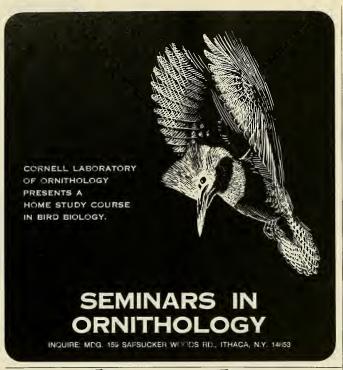
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of living ground sloths in southern Chile came 13,000 years too late.

The Shasta ground sloth belonged to a third group, the megalonychids. This species was the smallest of the North American genera if we exclude a few relatives that found their way into the Greater Antilles. The pony-sized Shasta ground sloth had short legs, a bulky paunch, and may have weighed 300 to 400 pounds. In its Pleistocene heyday-the time of the mammoths and native North American camels and horses-it ranged from northern California and the Texas Panhandle, south into northern Mexico. Except for the famous La Brea tar pits, in what is now downtown Los Angeles, the Shasta ground sloths' fossilized bones are not very common, suggesting that they weren't either.

Almost fifty years ago an articulated Shasta ground sloth skeleton, virtually complete with even the small foot bones held together by dried ligaments and tendons, was found in the bottom of a fumarole on the side of Aden Crater, New Mexico. Speculating on its age, Professor Lull of Yale University found that "its amazing condition of preservation gives one the feeling that it cannot be more than a few hundred years old." History was repeating itself. As in the case of the mylodont hide from Chile, it was hard to dissociate the idea of elegant preservation from the thought of recent age. Nevertheless, Lull assigned the mummified carcass to a much earlier time, an interpretation subsequently supported by radiocarbon dates, which showed that the animal died at least 10,000 years ago.

One aspect of Shasta ground sloth ecology is well known. That is the matter of their diet.

Paleobotanists have long appreciated sloth dung for its value in determining the ancient plant communities of arid regions. Richard M. Hansen of Colorado State University recently examined plant fragments from various levels in the sloth dung deposit of Rampart Cave. He found that the sloths browsed on cat's claw (Acacia), Mormon tea (Ephedra), globemallow (Sphaeralcea), saltbush (Atriplex), mesquite (Prosopis), and succulents (Opuntia, Yucca, Agave). Pollen of Mormon tea and globemallow is much more evident in the dung than in soil samples taken from outside the cave.

Near Rampart Cave these plants flower only in late winter or in early spring. Late winter is also the best time for finding green forage at the low elevations in this arid area, and I believe that was the time of year the sloths used Rampart Cave.

Also, from the occasional presence of embryonic sloth bones, I suspect that females used the caves

to give birth.

Acting as a coroner's jury, Long and I hoped to determine the cause of the Shasta ground sloth's extinction. Our first need was to determine when the animals of Rampart Cave died. By radiocarbon dating of their dung, we could at least discover when they lived, and we hoped that by judicious sampling from the top of the deposit, we would discover the time in the prehistory of the Grand Canyon when sloths last occupied both Rampart and Muay, an adjacent ground sloth cave.

From fifteen radiocarbon-dated samples collected at various depths, we determined that the sloths first entered Rampart Cave more than 40,000 years ago. For some reason, they left about 32,000 years ago, abandoning the cave to pack rats.

Twenty thousand years later, the sloths returned to their favored shelter. Between 13,000 and 11,000 years ago, they flourished, judging by the quantity of dung deposited during that interval. The youngest of our dung samples was 10,780 years old. About that time, the Shasta ground sloth seems to have died out suddenly, not only at Rampart Cave but at similar caves elsewhere.

I doubt that the Shasta ground sloths spent much time in the cave. Had they done so, they would have soon filled it with dung. We estimated that the average annual rate of deposition was only slightly more than one cubic foot a year, an amount that probably represented less than a week's elimination from one healthy adult ground sloth.

The summer season is oven hot at the bottom of the Grand Canyon. July and August rains, which renew plant growth in other parts of Arizona, rarely fall along the Grand Wash Cliffs. In the absence of tender new browse, I believe the sloths left the canyon in spring, to summer at higher and cooler elevations. At 5,000 feet, site of the present Hualapai Indian Reservation, they would have found cooler temperatures and Joshua tree-juniper-sage-

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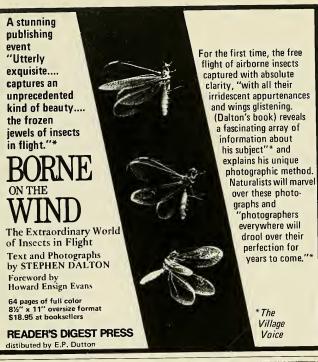
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brush woodland. (From dung studies in Texas and Nevada caves, we know that the sloths browsed on woodland trees and shrubs.) The vertical migration from canyon bottom to the woodland area would have taken no more than a few weeks at a possible sloth travel rate of a few miles per day.

Various dietary studies that have been conducted on the fossil dung of the Shasta ground sloth show that its favorite food plants—in the Rampart and Muav cave areas, Gypsum Cave, Nevada, the sloth caves of the Guadalupe Mountains of west Texas, and Aden Crater, New Mexico—are still important components in the vegetation of arid

regions in North America. Thanks especially to the remarkably stratified record of Shasta ground sloth diet available from the dung deposits at Rampart Cave, we know that for thousands of years they browsed on a variety of desert and woodland shrubs, including species presently favored by wild desert bighorn sheep and feral burros. Over thirty genera of plants identified in sloth dung remain important in the natural vegetation at or near the Grand Canyon sloth caves. It is not easy to account for the Shasta ground sloth's extinction by loss of food

Why, then, did the sloths vanish? That is the question Long and I were pondering on our winter's trip to Rampart Cave. Although I discount the idea, one cannot exclude some drastic and sudden climatic catastrophe, perhaps one that briefly blighted the land, leaving no trace of its occurrence. I have more faith in another possibility, no less catastrophic in terms of the sloth's

ability to survive. Archeologists have determined that 11,200 years ago big game hunters pursued mammoths along the San Pedro Valley of southern Arizona. These hunters seem to have suddenly appeared in the western United States at this time. Admittedly, Paleo-Indian artifacts, including the Clovis spear points that are occasionally associated with mammoth bones, have not been found in association with the ground sloths. In fact, no archeological material has ever been found in convincing association with sloth bones or dung. But lack of kill sites is not necessarily proof against the overkill theory, which holds that the massive extinction of the New World Pleistocene megafauna was caused by human hunters in a relatively short period of time. Abundant kill sites may never be found, and the true nature of the human impact may not be recorded in our fossil record—which is all too incomplete as paleontologists commonly complain.

But the fact remains that the sloths died out just at the time when, according to archeological evidence, the first big game hunters arrived in North America. Slow, lumbering, and leaving large and distinctive droppings, the ground sloths would have been easy to track and kill. There is no reason to believe that the first hunters could perceive, much less control, the impact of their arrival on the more vulnerable and easily destroyed native large mammals of North America. Enjoying an abundant food supply and not threatened by any serious enemies themselves, the hunters could have increased very rapidly.

I do not exclude the possibility of a rate of increase as fast as a doubling in numbers per generation. Within a few hundred years the human predators could have swept over most of North America, obliterating much of the big game.

A front of highly skilled hunters could have swept through any one region in a few years, leaving little evidence for archeologists to fish out of the fragmentary fossil record.

If I am right, and I admit that other possible explanations for sloth extinction exist, the best evidence for man's presence in any region may, paradoxically, be the absence of ground sloths and other large, vulnerable prey. The youngest dates on ground sloth middens may say as much about human culture as the oldest dates on human artifacts.

For this reason, I hope anthropologists will join paleontologists in treasuring the scientific significance of ground sloth dung. From the dung we have an opportunity to study both the ecology and the natural history of a remarkable group of animals.

Because the caves containing sloth dung are not numerous, and the contents perishable, their value is accordingly great. The sloth caves deserve the same protection as that afforded ancient ruins of prehistoric peoples. We have much more to learn about a mysterious moment, about 11,000 years ago when, for the last time, the dung came down.

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Red, White, and Mysterious

The case history of a star that defies explanation

The brightest star of the night sky, so prominent one can hardly avoid noticing it, remains an enigma despite two thousand years of observation. The star is Sirius, the "Dog Star." In ancient times it was referred to as red: today it has a brilliant white color, but no physical theory yet proposed can account for the change.

Sirius is a binary star—one of two stars close enough together to revolve around their common center of gravity. Its small companion, known as Sirius B, appears to be much older than Sirius itself, although according to accepted theory, the two stars should have been born together. Finally, the presence of a second and still smaller companion, Sirius C, has been deduced by several astronomers through mathematical and physical reasoning, and some skilled observers have even reported glimpses of this elusive object. But the best photographs don't show it. and modern computations say it isn't there.

In the first century B.C., Horace told of the "red Dog Star," and in the following century. Seneca called Sirius redder than Mars. Claudius Ptolemy in the Almagest (ca. A.D. 140), his famous compendium of more than one thousand stars visible to the unaided eye, listed Sirius both as one of fifteen objects of the first (that is, brightest) magnitude and as one of six reddish stars. Moreover, long before Ptolemy, the now-forgotten author of a cuneiform text noted that Sirius (which he called

Kak-si-di) "shines like copper." Yet the color of Sirius has been known to be white at least since the tenth century A.D., when the Arab astronomer Al-Sûfî the Wise recorded it.

Astronomers and classical scholars have vigorously debated the description of Sirius's color in the *Almagest*. Some ascribed the reputed red hue variously to an error of the author, the transcriber, or the translator. The controversy was almost forgotten until it was revived last year by the Austrian astronomer Karl Rakos, on the basis of a new measurement of the light from the companion star Sirius B.

The basic problem faced by Rakos, as by all earlier observers of Sirius B, is the proximity of this dim star, aptly named "the Pup," to the brilliant Dog Star. The bright light of Sirius proper (known technically as Sirius A) can overpower the instruments that astronomers employ to record the fainter emissions of Sirius B. Indeed, for eighteen years after the existence of the Pup was first deduced in 1844 by the German astronomer Friedrich Wilhelm Bessel from a tell-tale wobble in the motion of Sirius A across the sky. astronomers searched to no avail for the companion. They concluded that the unseen star, whose gravitational force presumably caused the wobble of Sirius A, must represent a new kind of object, one they dubbed a "dark star." Bessel, noting that the companion was apparently invisible, wrote, "We have no reason to suppose that luminosity is a necessary property of cosmical bodies."

Finally in 1862, the Pup was sighted for the first time when the father-and-son opticians Alvan and Alvan G. Clark of Cambridgeport,

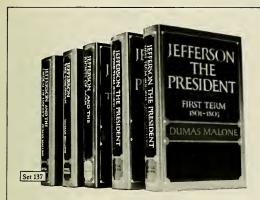
Massachusetts, were testing a superb 181/2-inch telescope lens they had just completed. Alvan G., entirely unaware of the past two decades of learned speculation on the existence of Sirius B, was viewing the image of Sirius A when he exclaimed, "Why, father, the star has a companion." Bessel's deduction was thus proved correct, there was a second star. But the companion was fully ten thousand times fainter than Sirius A, although its mass is nearly half as great as that of the brighter star. The key difference is in size. Sirius B, the first known example of the so-called white dwarf stars, has the diameter of a mere planet, only a few times larger than the earth. Yet its mass equals that of our sun. It is truly a condensed object; one cubic inch of its material weighed on the earth would amount to a ton.

Astrophysicists regard white dwarfs as a class of dying stars. According to the generally accepted scenario of star evolution, a star such as the sun will eventually expand into a huge, cool object, or "red giant." big enough to fill space almost to the orbit of Venus. Then it will eject a shell of matter, called a planetary nebula, that glows brightly but dissipates into space, and the star within, small and hot once again, will become a white dwarf that will slowly shrink, fade, and cool throughout eternity.

Rakos's new measurements, which he made with a one-meter diameter telescope at La Silla, Chile, suggested to him that Sirius B is "the brightest and hottest white dwarf we know." This also implied that the Pup might be the newest white dwarf yet found. Rakos's work revived the suggestion that Sirius B

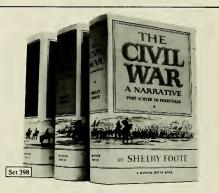
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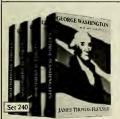
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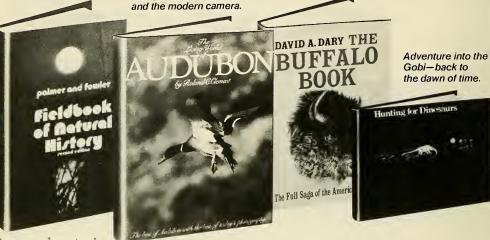
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might actually have been a red giant only two thousand years ago. The ancient red color of Sirius would then have come, not from Sirius A, but from Sirius B, which would in those times have been larger, brighter, and redder than it is now.

This explanation sounds logical, but unfortunately it contradicts much of what we know-or think we know-about the life cycles of stars. To begin with, even optimistic astronomers calculate that the time required for a red giant to become a white dwarf is much closer to 100,-000 years than to 2,000 years. Moreover, Malcolm P. Savedoff, a University of Rochester astrophysicist who has puzzled over the Sirius problem for years, calculates that Sirius B would have been only a rather modest red giant, which produced most of its light at wavelengths to which the human eye is insensitive. Indeed, he believes that Sirius B as a red giant could have been much fainter to the eye than the white Sirius A, and thus would not have appreciably affected the color seen in Ptolemy's time. Modern astrophysics, Savedoff has concluded, cannot account for the reported or alleged red color of Sirius in historical times. The one new observation, that of Rakos, has also been called into question by Irving W. Lindenblad, an expert on Sirius observations at the U.S. Naval Observatory in Washington, D.C. He believes that Rakos's measurements were disturbed by the light of Sirius A.

A second puzzle of the Sirius system is that Sirius A is, at first glance, a normal star, while Sirius B is a white dwarf. The conventional theory of the stellar aging process tells us that the more massive stars pass through the life cycle of normal star to red giant to compact object (that is, white dwarf, neutron star, or black hole) much more rapidly than do the smaller stars. In effect, "big fires burn out faster." Further, the leading theory of binary star formation requires that both stars in a binary system must form at the same time from the same cloud of gaseous matter. Consequently, Sirius A and B are presumed to have formed at the same time, and since A is more massive than B, it should be more advanced in the life cycle. But precisely the opposite seems to be true: B is already a white dwarf, while A has not yet even become a red giant.

One way out of this seeming

paradox is to postulate that Sirius B once was the more massive of the two stars, that it swelled out into a red giant, and that the outer layer of its material was gradually captured by the gravity of Sirius A (some material also being lost into space). Such effects of "mass transfer" are actually known to occur in the "contact binaries," double stars whose orbits are so small that the stars almost touch. But a leading expert on contact binaries at the University of South Florida has written that the two stars of the Sirius system "are so widely separated that virtually no physical interaction occurs between them."

Where, then, can the solution lie? Perhaps we must consider not only how stars evolve but also how their orbits evolve. The Dutch astronomer E. P. J. van den Heuvel, of the Utrecht Observatory, has calculated that in certain cases a close binary system can undergo mass transfer, with the larger star losing up to almost 90 percent of its mass, in a manner that causes the stars to draw apart. According to this hypothesis, Sirius A and B might once have been closer together, and material from the then-larger star B might have been transferred to A. According to the van den Heuvel theory, two consequences would result from such a situation: Sirius A would be observed today as a slowly rotating star and would exhibit in its spectrum evidence of chemical composition that differs from that of a normal star such as the sun. The latter effect would be the result of the transfer



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The tiny spot of light below Sirius's large and brilliant image is the star's companion Sirius B. The possibility that a second small companion also exists has been suggested.





of matter from the red giant star B to Sirius A.

Precisely these phenomena have been observed. In particular, observations by a Soviet astronomer at the Crimean Astrophysical Observatory and by an American astrophysicist, using the 100-inch telescope at Mount Wilson Observatory in California, indicate that Sirius A has too much barium and yttrium and too little beryllium, calcium, and scandium to be a normal star. These findings have led to the conclusion that Sirius A may indeed have been contaminated with matter from Sirius B, as the van den Heuvel hypothesis would require.

These results have helped convince some stellar experts that the processes of both stellar and orbital evolution have produced the present, puzzling state of the Sirius system. If the experts are correct, then Sirius B once was a massive red giant that would have been bright enough to attract the attention of observers on earth. But this evolutionary stage would have occurred much further back in time than previously supposed. It has been pointed out that if there were men around on earth to see this postulated red star, they must have been Neanderthals or members of some other, now extinct prehistoric race. It seems inconceivable that such observers, if they noted the phenomenon, could have passed the knowledge on down to the time of the early Christian Era.

The final puzzle of the Sirius system is Sirius C, the hypothetical "third body." Its possible existence was first suggested in 1918 by an astronomer working at Greenwich, England, who examined measurements of Sirius A and B made since Clark discovered the Pup in 1862 and found that the binary stars' orbital motions might make better sense if another, smaller star were present, exerting an additional gravitational force. A similar conclusion was reached a few years later by a German astronomer working at Göttingen, and the problem was also considered by astronomers in France and Italy. The first report of an actual sighting of Sirius C came from Philip Fox of the Dearborn Observatory at Northwestern University in Evanston, Illinois. A well-known astronomer, Fox examined Sirius on thirty-three occasions from 1915 to 1924 and wrote of a 1921 observation that "B appears persistently double." Thus C was conceived of as a close companion of B.

Sirius C was also seen in 1926 by several astronomers at the Union Observatory in Johannesburg, South Africa, one of whom described it as about forty times fainter than Sirius B. Another one of the South African astronomers even measured C's position and searched for C on a number of subsequent occasions with mixed results. Sometimes he believed he saw it again and would measure its distance from B; at other times C was definitely not visible, and he finally wrote, "I cannot feel confident that I am measuring an actual star-image; at the same time I cannot convince myself that I am the victim of an optical illusion."

A totally different argument for the existence of Sirius C came in 1968 from the Dutch astrophysicist J.R.W. Heintze. His reasoning depended on abstruse considerations of the physical properties of Sirius A and led him to conclude that C was a close neighbor of A rather than B, although those observers who thought they had seen C had found the contrary to be so. Then, in 1973, Lindenblad, the Sirius expert at the U.S. Naval Observatory, analyzed a series of observations of A and B made with the best modern techniques and concluded that they showed no evidence for the existence of a third body. That seems to be the most reliable conclusion to date.

One evening late in March of this year, I went to the Naval Observatory for a firsthand look at the subject of this article. Sirius was shining brightly, low in the twilight sky, as I stepped onto the movable floor of the observatory. Seen through the 26-inch telescope, B was a tiny point of light below and to the right of Sirius A, the brilliant white star that, unaccountably, seemed red to Ptolemy. C, if it exists, could not be seen. Nevertheless, as data accumulate over the years, it will be possible to check the orbital motions of the Sirius system with increasing accuracy and to search with higher confidence for the possible presence of Sirius C.

This is astronomer Stephen P. Maran's fourth article for Natural History. A researcher at NASA's Goddard Space Center in Greenbelt, Maryland, he is also editor of Astrophysical Letters and coauthor of a college textbook on astronomy.

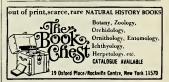
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"Eye of newt and toe of frog, wool of bat, and tongue of dog...Cool it with a baboon's blood, then the charm is firm and good." Witchcraft like religion, deals with controlling problems through complexly coded ideas and rituals. Why are there similarities and differences in magic and witchcraft from society to society? In what social contexts is witchcraft used? This series will be a serious socio-historical inquiry into various beliefs and practices of magic, witchcraft, and sorcery. Paul J. Sanfacon is Lecturer in Anthropology at the Museum.

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An informal series of slide-illustrated talks on some of the fascinating aspects of the world of insects. Sessions will include discussion of structure, life-histories, environmental relationships, and the significance of insects to man. Presented by Alice Gray, Scientific Assistant in the Museum's Department of Entomology.

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Six lectures on Thursday evenings starting October 9, from 7:00-8:30 p.m. Fee: \$25.

Explore the world of rare orchids and insect-trapping bog plants. See colorful alpine flowers that cling to rocky windswept mountainsides. These, together with wild flowers of forests, meadows, pine barrens and seashores are discussed in this series of slide-illustrated lectures. Helmut W. Schiller is Lecturer in Botany at the Museum.

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Celestial Events

by Thomas D. Nicholson

Sun and Moon: The sun is in the constellation Leo in mid-August and moves into Virgo about September 16. Its eastward motion is now taking it southward at a rapid rate, noticeably shortening the days. On September 23, the sun crosses from north to south of the Equator.

The moon shows up as an evening object during the second week each month, becoming full a few days after mid-month. Phases for the period are as follows: in August, new on the 7th, first-quarter on the 13th, full on the 21st, last-quarter on the 29th; in September, new on the 5th, first-quarter on the 12th, full on the 20th, last-quarter on the 28th; in October, new on the 4th, and first-quarter on the 11th. The full moon on September 20 is the harvest moon.

Stars and Planets: No part of the sky is more rewarding for viewers in the Northern Hemisphere than the rich field in the southwestern sky of late August and early September. That is the area where the center of the Milky Way passes through Sagittarius and Scorpius. Don't fail to look for the Great Cluster in Hercules, well up in the west, its thousands of closely packed stars so bright that the cluster can be seen with the unaided eye. As for meteor showers, look for the Perseids in the hours after midnight from the 11th through the 13th of August. If skies are clear, this shower—the best of the year—is guaranteed to produce results.

After having Venus all last spring and early summer, the evening sky is dull without it. The planets now dominate the morning sky, except for Mercury, which makes a rather inconspicuous play at being an evening star. About dawn, you'll see Venus just coming up in the east, Saturn to the right and well up in the southeast (near the twin stars in Gemini), Mars farther to the right (near Aldebaran, in Taurus), and Jupiter low in the west, where it sets soon after sunrise.

August 12: Perseid meteors reach maximum.

August 15: Jupiter, stationary, begins retrograde motion.

August 23: Moon at apogee, farthest from earth.

August 27: Venus, at inferior conjunction, moves from the evening to the morning sky.

August 29-30: Mars is very close to the moon tonight.

September 5–6: Look for very high tides as the effect of the perigee moon (nearest earth) enhances the spring tide.

September 8: Spica, in Virgo, is near the moon tonight.

September 16: Venus is stationary and resumes direct (eastward) motion through the stars.

September 20: The harvest moon coincides with apogee.

September 23: Autumnal equinox. Fall begins in the Northern Hemisphere.

September 26: Mercury begins its retrograde (westerly) motion.

September 26-27: Mars is near the moon late tonight.

September 30: Saturn is near the moon early this morning.

October 2: Venus rises close to the moon just before sunrise. October 3: Venus is at greatest brilliancy as a morning star.

October 4: The perigee moon again occurs near new moon, enhancing the effect of spring tides.

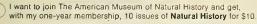
October 9: Mercury enters the morning sky.

October 13: Jupiter is at opposition from the sun. It now rises at sundown, sets at sunrise.

★Hold the Star Map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 12:25 A.M. on August 15; 11:25 P.M. on August 31; 10:20 P.M. on September 15; 9:25 P.M. on September 30; and 8:20 P.M. on October 15; but it can be used for about an hour before and after these times.



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Opening Old Wounds

THE HEALING HAND: MAN AND WOUND IN THE ANCIENT WORLD, By Guido Majno. Harvard University Press, \$25.00; 571 pp., illus.

A reviewer is not ordinarily expected to go so far as to read a book he writes about: he is more likely to skim it, note its drift, find a few errors he can use to display his own erudition, and of course, select a passage or two, not entirely at random, to be quoted. Or he may use the book as a springboard for a dive into the pool of his own special interests and prejudices, in which he swims until, like Mark Twain with the German verb, he emerges on the far side with a mouthful of the substance of the book in question. If I am unable to apply either of these dodges, it is because from the beginning I found Majno's book so absorbing that I was hardly able to put it down, even though I am as busy with other work as most other readers of such a book are likely to be. It is a book for students of all ages and all sorts: students of medicine and surgery and other healing professions, students of science, including anthropology and archeology; in short, students of man-his work, his development, his language-students without restriction within the species.

The central theme of the book, around which the author embroiders many pleasant diversions, is the history of surgery from the earliest times to Galen to the fall of the curtain of darkness in medieval Europe. I might have liked to see Majno go a little further, into the Arabian medicine and science that kept the light of learning alive while it flickered in Christendom. But he does devote a chapter to ancient Arabia, and he mentions the later period in a few paragraphs at the end of the book. He has, after all, limited his province to "the ancient world" of his title.

Guido Majno was born in Italy

and has been professor of pathology at Harvard, Geneva, and the new Medical School of the University of Massachusetts in Worcester. He has given ten years of what must be a busy life to the compilation and writing of this book, with help from experts in many parts of the world, as well as from associates, friends, and family, all of which he acknowledges gracefully. He has gone

back to original sources and, in order to do so, has acquired a working knowledge of all the languages he needed—Sumerian, hieratic, Greek, Chinese, Latin, Sanskrit—and his lucid and graphic explications of the structure of the more recondite of these tongues are among the unexpected treasures of the book. Such subjects, and the text in general, are set forth with an admirable mixture



of patience and humility. He wants us to share his enjoyment of his subject and goes about seeing that we do without a trace of condescension. This is the difficult art of popularization, often attempted, seldom accomplished so successfully. One reads with a sense that Majno is there in person, talking pleasantly, gently, wittily; and as he goes along he has a wealth of pictures to show us to make his points clearer—drawings, diagrams, maps, and photographs, many in color.

Majno knows that the early history of surgery is not a source of pride for doctors. Ordinarily the best thing to do with it is to sweep it under the rug. Before there was real anesthesia-which came only in the mid-nineteenth century-surgery and torture were not easily distinguished. But as anesthesia widened the scope and lengthened the duration of operations, the ancient scourge of surgery, infectionwhich waited another thirty or forty years to be understood-became a nightmare, and the surgeon turned into a latter-day Abhorson, the executioner in Measure for Measure, who hesitated to use Pompey as an assistant for fear that "he will discredit our mystery." It was Lister, of course, and behind him Pasteur, who made modern surgery possible, but more of this in a moment. Maino makes us see that the problems that made attempts at surgery unavoidwounds-have able—principally been with us from the beginning; we learn from him that the surgeon's efforts to deal with them have been by turns heroic and pathetic, often ingenious, always eminently human. A central motif or moral of the whole tale-if this is not a reflection of my own prejudice—is a pervasive theme that runs through the whole history of science: for example, how the practical Egyptians did better than the purely theoretical Greeks, who insisted on reducing all knowledge to perfect philosophical models that were more ornamental than useful;



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how philosophy without the test of practice, the arrogant notion that man can understand through the medium of thought alone, helped to delay the advent of true understanding for two thousand years.

Infection is the ultimate obstacle to the healing of wounds. In its absence most of them will heal without any outside aid. Lister did not quite understand this, but he opened the doors so that others could do so. Lister's antiseptic surgery showed that infection was not inevitable, as it had been believed to be almost continuously before his time—with notions to the contrary, as Majno points out, in Assyria, in Egypt, and in the writings of Ovid, whom he quotes:

We see wounds grow larger by being treated, Which would have done better untouched.

He quotes Celsus: "And a wound can be treated without foreign and far-fetched and complicated medicaments." But even for Lister it was almost too much to imagine that wounds could be treated without any medicaments at all.

As early as 1878 Pasteur had made this comment on Lister's work:

If I had the honor of being a surgeon, since I am convinced of the dangerous conditions which can be caused by the germs of microbes which are to be found everywhere, especially in hospitals, not only would I use only instruments in a perfect state of cleanliness, but also after having cleaned my hands with the greatest of care, I would flame them rapidly, a practice not much more dangerous than a smoker passing a hot charcoal from one hand to the other, and I would only use bandages, cloths and sponges which would have been exposed to air heated at 130 to 150° [C]. I would use only water which would have been heated at 110 to 120°. (Three Centuries of Microbiology, McGraw-Hill Book Co., 1965.)

Lister lived to see aseptic surgery replace his antiseptic methods, and since the mid-1930s, following Ehrlich's earlier pioneering, we have seen chemotherapeutic and antibiotic drugs—which attack microbes with minimal effects on the host—replace antiseptics almost everywhere. Al-

most, because the notion of antiseptics-ordinary chemicals that can be used to kill germs on the skin or mucous membranes or in woundsalthough nearly always fallacious, is kept alive partly by the ancient tradition of which Majno speaks in many places, and partly, in our present sophisticated world, by the profits that can be made out of it. Even Majno, who obviously knows the facts, is beguiled into assuming that the ancients may have used myrrh and verdigris and cinnabar effectively in the treatment of wounds. He even describes his own experiments and unaccountably permits himself to suggest that a drug that inhibits the growth of bacteria in a petri dish will necessarily do the same in a wound. But it is a small thing; and Majno's idea of doing his own experiments to check the statements in the ancient records is one of the delightful touches in his book.

Here is another one. In several places Majno speaks of the use of incantations and other aspects of religion in medicine and describes them as early forms of psychotherapy. For example, the Indian vaidya ("one who knows," a physician) differed in this respect from his Greek counterpart, who "had split away from religion and from the psychotherapy it afforded, leaving both to the temples of Asklepios. The vaidya, instead, practiced the whole gamut. To him, religious acts were medicine of the first order. Nowhere as in India did religion mingle so thoroughly with private and public behavior.

This sort of thing will be appreciated by today's young people who follow Allen Ginsberg in the value they place on the mantra. Majno defines this word as "a short prayer, a word, even a single letter"; but he objects that "the vaidya continued to believe that the mantras never failed: 'The Mantras, full of occult energy and perfect truth and divine communion, never fail to eliminate the poison from the system, and hold their own even in cases of deadliest poison.' [This in connection with a case of cobra bite.] And there is a good chance that the mantras did work. The local treatment was of a nature to help. In India, moreover, well over half of those who have been bitten by poisonous snakes escape without any symptoms of poisoning. Many recover from cobra bites even without any effective

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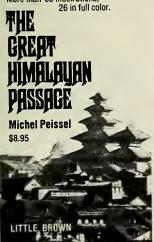
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treatment, perhaps because the snakes inject little venom when biting defensively.'

There are references to two modern treatises on snakebite. The principle is clear, of course: the deadliest poisons have their minimal lethal dose (or the statistically more reliable dose that kills half the test animals, the LD₅₀); and there are more potent poisons than cobra venom. But here as elsewhere in this book Majno has made a judicious mixture of old and new, of mysticism and science, helping us to understand how some of the empirical remedies of the ancients, such as the juice of the poppy capsule (opium) in Egypt and Greece, rauwolfia (reserpine) in India, the first tranquilizer, and ephedron (ephedrine), described by Pliny the Elder as styptic and antiasthmatic, were combined with wines, perfumes, and various means properly classified as psychotherapy to give the earliest surgeons more of a basis for effective treatment than mere chance or witchcraft.

This is a book for the serious reader as well as the browser, for the searcher after information not easily found elsewhere as well as for the one who asks only to be diverted by stimulating, well-written, and handsomely illustrated work. But the serious reader might offer a small complaint. There are separate notes at the end for each chapter, which is standard, and the reader is helped to use them by running marginal notations of the pages in the text to which they refer. But the separate bibliographies for each chapter, also at the end, are identified only by inconspicuous chapter headings at the top of each long list. A single bibliography would have avoided the annoyance of holding two places in the book—in the text and among the notes-while hunting back and forth for the appropriate item in the bibliography. This defect seemed the more glaring to me for being so far out of harmony with everything else in the book, in which Majno gives every indication that he had the interests of his readers tenderly in mind throughout, a quality for which he deserves a full measure of gratitude. A splendid book.

Theodor Rosebury is professor emeritus of bacteriology at Washington University, Saint Louis, and author of Life on Man and Microbes and Morals.

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Salt Talk

This vital ingredient has been the subject of a war, a tax, and much folklore

I am a halophile; I crave salt. As a boy, I gladly swallowed those spoonfuls of salt that had to be forced on my friends in hot weather. Today I have to guard against an infinite appetite for potato chips and salted nuts. I also know that if I really follow my own 'taste' in salting food, I ruin dinner for most people, except for NaCl true believers like myself.

Between salt lovers and salt haters, the gap is wide: partly as a pure matter of taste, of individual preference; partly, it seems, as a result of cultural training. Americans expect more salt in their food than the French. This, at least, was the assumption of Julia Child when she adapted the "art of French cooking" to American kitchens.

Assuming this is an accurate perception (and informal experiments with French friends bear it out), I still am unable to account for my own, more than routinely American salt hunger. No doubt, my upbringing, which all but proscribed sugar but condoned salt, created a favorable microclimate for halomania. I suspect also that my body chemistry and metabolism leave me with a habitual salt deficit to make up. Apparently, the body is capable of translating its chemical and nutritional needs, to a degree, into specific thirsts and hungers even when we do not consciously perceive that we are short of the particular substance in question.

In the case of salt, individuals do vary so widely in their needs that it is reasonable to suspect that each metabolism is setting up its own requirements. We do know that the adrenal hormone aldosterone guides the kidneys in controlling the rate of salt excretion through the urine. If this mechanism goes awry, it can lead to excessive salt retention or to an internal salt shortage. Either way, the swing of the pendulum can provoke serious trouble, since salt is a crucial element in basic cell processes. Salt or its constituents, sodium and chlorine, are vital ingredients in the chemistry of muscle contraction, of triggering nerve impulses, digesting protein, and maintaining cell osmosis.

Whether, under normal medical circumstances, a salt-deprived person will crave and forage for salt is not, I think, rigorously known, although it is probable, and archeological evidence backs the assumption. The systematic exploitation of natural salt deposits did not begin until Neolithic times, when men had begun to settle down to farming and a diet of unsalty carbohydrates. Theretofore, hunting communities had ingested sufficient salt in meat and fish.

From the dawn of agriculture, however, salt has never ceased to be an item of importance, sometimes of cataclysmic importance, in human affairs. Two Germanic tribes of antiquity, says Tacitus, held a natural salt spring in such awe—prayers uttered in its vicinity received a more favorable hearing—that they fought a war over it.

Salt was precious everywhere before the modern era. The Chinese
were taxing it as early as 2000 B.C.
The Roman consul who imposed a
salt tax to defray the military expenses of the Second Punic War became known as Livius Salinator.
Likewise, salt attached its name to
the Roman soldier's pay (originally
his salt allowance) as salarium, or
as we would say, salary.

Odd as it now seems, the idea that salt was a valuable commodity actually persisted into this century. The infamous French salt tax, the gabelle, was not only one of the chief

explicit causes of the 1789 revolution, it also endured as a unique category of taxation in France into the 1940s. In Vietnam, the French colonizers maintained an official monopoly on salt (and opium).

While the salt trade out of Syracuse, New York, which was the original reason for digging the Eric Canal, has disappeared, camels still bring salt across the Sahara, although Timbuktu's days as a center for salt or anything else seem numbered. No doubt the African custom of using salt to pay a bride price is also on the wane. But we should not regard monetary salt as an eccentric custom of landlocked, primitive peoples. Marco Polo reported that the Great Khan of Cathay had struck coins of salt marked with his seal.



Sixteenth-century engraving dep solar evaporation of

And when the Italians marched into Addis Ababa in 1936, they found salt tablets called amoulies on deposit in an Ethiopian bank.

If salt is no longer as good as gold, it does continue to have currency in contemporary folklore and superstition. Indeed, it is unnecessary to rehearse old wives' tales about birds' tails and such. It is enough to mention a true bit of folk wisdom. Throwing salt on spilled red wine helps prevent a stained tablecloth.

Today, we can afford to throw salt around and over our shoulders largely because the technology of salt has advanced to the point where salt itself is one of the cheapest items on our shopping lists. In the old days, salt's high cost reflected the cost of transport and processing. Salt had to be evaporated out of seawater or naturally brackish springs. In warm places, the sun provided the energy for evaporating so-called solar salt. In northern areas, fires were kept burning under evaporation pans. Both methods were inefficient and produced highly impure salt that was constantly subject to bacterial contamination from halophilic organisms, ones that thrive in high concentrations of salt and impart a red (at times green) color to the batch.

In more recent times, we have learned to extract salt easily from the ground and to evaporate it cleanly. Deep deposits are flushed out of the ground as brine-that is, miners pump water into the salt deposit, dissolve it, and then collect it for evaporation. Modern salt evaporators control purification with systems of vacuum pans, high-pressure heaters, gravel filters, and centrifuges that dewater the salt. Salt manufacturers now also usually add magnesium carbonate and certain silicates to prevent clumping in humid weather, and they put in iodides for consumers in landlocked areas who might otherwise develop goiter from an iodine deficiency.

These additives have made some

people shy away from ordinary commercial salt and turn to more traditional sea salt. There are also those who believe that evaporated salt from the ocean is categorically different and somehow more natural than what I suppose we should call earthbound salt, salt from mines. This is a delusionary distinction. According to geologic research, all salt deposits are of aqueous origin, and salt has never turned up in a primitive rock formation. In other words, all of the 350,000 cubic miles of salt deposited in the earth is sea salt; it originally came from the sea. The difference between it and salt from the sea is in the method of evaporation and in the chemistry of packaging. But fine-grained, highly processed, industrial salt lacks the character of old-fashioned, coarse sea salt with its flavorful impurities. This homely advantage counts especially if the salt is being used to cure fresh meat, for then the flavor of the salt transfers itself to the ham or cod or whatever. Artificial additives do not contribute to the efficacy of the curing process.

Accordingly, anyone who wants to follow in the footsteps of those generations without refrigeration, anyone interested in preserving food through salt curing should use sea salt without fail. The process is exceedingly simple and worth doing because it lets you buy very inexpensive fresh pork, for example, and turn it effortlessly into a basic but delicious meat prized in French country cooking.

First, make sure you have a curing area with a constant temperature between 38 and 40 degrees Fahrenheit (the temperature at which a refrigerator should run). Then buy ten pounds of fresh pork picnic shoulder with the bone in. Cut away the rind, scrape as much fat off of it as you can, and set aside. Bone the meat (the bones can be used in soup) and cut into large slabs.

In a bowl, mix 1½ cups sea salt,

1/4 cup sugar, l teaspoon saltpeter (available at pharmacies), 11/2 teaspoons crushed juniper berries, 3/4 teaspoon white pepper, 1/4 teaspoon allspice, ½ teaspoon thyme, and 1 crumbled bay leaf.

Rub half the mixture thoroughly over the surface of the meat and rind. Pack the meat, with the rind on top, into an enamel bowl, cover with plastic wrap, weight down with a brick, and refrigerate for five days. Then rub in the rest of the salt mixture, cover and weight again, and refrigerate for another ten days or for as long as six weeks. Turn the meat every few days and do not discard the brine.

This is the way French farm wives have been curing every known cut of pork-from jowls to hams-for centuries. Smoking would add its special taste, but it is not necessary. Even the renowned hams of Bayonne in the southwest of France are merely salt cured and then, usually, sliced and served raw. Should you try to cure a whole ham, you will probably not get the same high quality as the French do because the pork itself will not match home fed, cosseted pork, nor will your salt come up to the character of the coarse salt of the Béarnais hamlet of Salies to

the east of Bayonne.

Still, the basic method of salt curing is the same. Macroscopically speaking, the salt incites the juices to flow out of the meat, while the salt itself penetrates into the meat. In time, the process reverses itself, but the flavor of the salt and spices remains. The sugar prevents the salt from overly hardening the meat. And the saltpeter produces an attractive red-pink color. Recently, the use of nitrates, such as saltpeter, in the manufacture of bacon, hot dogs, and other prepared meats has come under attack because of an alleged risk of cancer from the chemical. Whatever the medical verdict may ultimately be on this question, you can be certain of a few calming facts. Nitrates

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are not some new-fangled poison concocted for your destruction by the food industry. They have been added to salt-sugar cures since the late Middle Ages, when the consumption of salted meat was a far more significant dietary fact than it is today. Second, nitrates also help to speed the curing process of some meats and they control certain bacteria not repressed by salt.

Bacterial control is the key to the curing process. Salt is a natural bacteriostat: it stabilizes meat microbiologically, but it does not do so completely. Salt in the proper concentration stops the growth of most acid-producing bacteria but permits certain salt-tolerant bacteria to carry out the fermentation process that gives salted meat its characteristic taste.

Meanwhile, nitrate-reducing bacteria transform nitrates into nitrites. Then, the nitrites "fix" the color of the meat by furnishing the nitroso, or nitric oxide, component of the permanent pink pigment nitrosohemoglobin or, when heat is applied, nitrosohemochromogen.

Salt curing may seem like a fantastically sophisticated microbiological maneuver for prescientific people to have hit upon. But to them, unencumbered by notions of unseen flora and organic compounds, salt curing must have been the simplest thing in the world. All you needed was salt, a crock, and a well-fed pig. Then, after nature worked its magic, you could sink your teeth into the Neolithic version of a hammus Alabamus.

Jambon Persillé

This is one of innumerable ways of making the pork specialty of Burgundy. It can be done with any kind of cured ham or pork. If you have cured your own pork, soak the meat overnight (or for 24 hours, if it has cured for several weeks) in several changes of water to leach out excess salt.

- 4-6 pounds cured pork including rind, if any
- 11/2 cups chicken stock
- I bottle dry white wine
- 3 cloves garlic
- 1 bay leaf
- 5 sprigs parsley for the cooking liq
 - l teaspoon dried thyme
- 1 cup finely chopped fresh parsley White wine vinegar Gelatin (optional)



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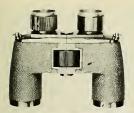
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- 1. Set the pork and rind in a large pot with the chicken stock, wine, garlic, bay leaf, parsley sprigs, and thyme. Add enough cold water to come one inch above the meat. Bring to a boil, reduce heat, and simmer partially covered for 21/2 hours or until meat falls apart easily when pressed with a fork.
- 2. Remove meat, discard rind, drain, cool, and pull apart into pieces roughly 1 inch by 2 inches.
- 3. Strain 21/2 cups of the cooking liquid and refrigerate. A layer of fat will solidify at the top. Discard it (you can treat all the cooking liquid in this manner and simply reserve the excess for use as aspic).
- 4. Dribble a small amount of the aspic from step 3 into a saucer. Set in the refrigerator for 15 minutes. If it solidifies, go on to the next step. Otherwise, dissolve a small amount of gelatin into the aspic, no more than a teaspoon, and do the refrigerator test again. Continue adding gelatin by half teaspoonfuls until your test sample jells.
- 5. Meanwhile, put the chopped parsley in a bowl and pour on enough vinegar so that it just begins to float. Let stand approximately 30 minutes.
- 6. Pour off excess vinegar. Then press the parsley lightly to get rid of any vinegar that will drip out under gentle pressure.
- 7. Combine parsley and aspic. Pour a thin layer of this mixture over the bottom of a glass bowl large enough to hold all the pork with room to spare.
- 8. Arrange pieces of pork over the parsley aspic. Try to pack in the meat pieces so that they dovetail fairly well. Continue alternating aspic and meat until the meat is entirely used up. Finish by pouring on enough aspic to cover the last layer of meat completely. Refrigerate overnight or until the dish has solidified. Serve cold, unmolded or directly from the dish, in pielike slices.

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Announcements

A Contemporary African Arts Festival continues through August 17 in Gallery 77 on the first floor of The American Museum of Natural History. This exhibition, the work of outstanding artists from nine African countries, includes more than 200 works of graphics, painting, sculpture, pottery, carved calabashes, resist-dyed textiles, counter-repoussé, leatherwork, architecture, and handloomed tapestries.

Trash Can Toys and Games can be seen through August in the Hall of Birds and the People Center, both located on the second floor of the Museum. This exhibit features the works of Leonard Todd, a Yale-trained architect; included are a space station built from delicatessen

containers and disposable coffee cup tops, a tin can castle with balconies made of half-pint containers, and games children can make from other throw-away items.

At the Hayden Planetarium of the Museum, "Universe Calling" examines our own galaxy, the Milky Way, and questions the possible existence of other life in outer space and time. Opening September 23, a new show, "A Year Full of Stars," will explore the stars and constellations as seen from all parts of the earth and examine the astronomical progress of the past forty years, including such new techniques as radio astronomy and space satellites, which have enlarged our view of the universe. Sky shows begin at 2:00

P.M. and 3:00 P.M. during the week with more frequent showings on weekends. Admission is \$1.75 for adults and \$1.00 for children.

Recorded Tours can be rented after 1:00 P.M., Monday through Friday and during regular Museum hours on Saturdays, Sundays, and holidays, at the Information Desk on the second floor of the Museum. The fee is 95¢ for adults and 60¢ for students, "The Director's Tour," narrated by Museum director Thomas Nicholson, guides the listener through the four floors of the Museum; Margaret Mead discusses Peoples of the Pacific; Eugene Gaffney takes the visitor back through time via the dinosaur halls; and Dean Amadon leads a worldwide ornithological tour.



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NATURAL HISTOI

Incorporating Nature Magazine Vol. LXXXIV, No. 8 October 1975

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Authors

While doing field work in Asia and Africa on environmental deterioration and its effects on agriculture, Erik P. Eckholm found that the subject of frewood came up in nearly every conversation he had. A senior researcher with Worldwatch Institute, a new environmental organization in Washington, D.C., he will report the results of his studies, including his work on the scarcity of firewood, in Losing Ground: Environmental Stress and World Food Prospects, to be published in April.





For thirteen years Kenneth L. Crowell has studied the population dynamics of mice living on the numerous islands of Maine's Penobscot Bay. "Populations come and go. You never have a one-time colonization," he explains. Crowell acknowledges that the mice are incidental to his real interest-population changes. He began by observing the varying number of bird species on Bermuda, but after a friend drew his attention to the isolated mouse populations on the Maine islands, he shifted his base of operations and the animals under study. When he is not on the islands, Crowell teaches biology at Saint Lawrence University in Canton, New York.

Carl J. Witkop, Jr. is a dentist whose speciality is genetic defects of the jaw and teeth. His discovery in 1956 of a group of Maryland Indians having a high frequency of albinism started him on a long-lasting study of pigment defects. In the past twenty years he has investigated albinism among numerous groups, including Southwest American Indians and the Amish of Ohio and Indiana. He is now studying a large number of albinos in Nigeria. The author of more than 150 technical papers in the field of genetics, Witkop is chairman of the Division of Human Genetics, School of Dentistry, University of Minnesota.



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"Basically, I'm a teacher; that's what I enjoy most," says anthropologist **Paul Shankman**, although he has spent about nine months on three separate trips doing field work in Western Samoa, the locale of his article. Shankman, who received his Ph.D.

from Harvard University, teaches at the University of Colorado in Boulder. His current and future research interests center on the impact of multinational corporations on indigenous peoples and the economic effects of migration on local economies.

"Butterflies have been an interest from the age of eight, when my father put a net in my hand." From that beginning, Thomas C. Emmel has gone on to study the behavior, ecology, genetics, and evolution of butterflies in Central and South America, the Caribbean, and east Africa. An associate professor of zoology at the University of Florida, his principal work now is a study of the coevolutionary relationships between butterflies and their food plants. The article in this issue is adapted from his book Butterflies, which will be published this month.



From an analysis of human skeletons, Richard G. Wilkinson hopes to get a picture of the biocultural status of past populations. His work has taken him to the Great Lakes region, the Gulf Coast of Texas, the Saratoga battlefield, and Mexico. Wilkinson, who avoids hobbies but participates in several outdoor activities, is an assistant professor of anthropology at the State University of New York at Albany.





An avid football fan, William Arens admits to having enjoyed about 5,000 hours watching the game on television. In his professional life, Arens is an associate professor of anthropology at the State University of New York at Stony Brook. His academic attention is about

equally divided between studies of Africa, where he has spent time working in northern Tanzania, and studies of American culture and society. He is occupied at present in coediting a book of anthropological essays dealing with the latter subject.



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The Firewood Crisis

by Erik P. Eckholm

For people in developing countries, retreating forests and rising wood prices could mean not enough fuel to cook their dinners

Dwindling fossil fuel reserves, price fixing by the oil cartel, and the dilemmas of nuclear power preoccupy diplomats, economists, and the global media. Yet another, equally momentous energy crisis—the plight of the third of the world's people that rely on firewood for cooking dinner—has been brewing for the last few decades, quietly neglected by governments and headline writers.

While chemists devise ever more sophisticated uses for wood, such as cellophane and rayon, at least half of the timber cut in the world still fulfills an ancient function for humans: as fuel for cooking and, in colder mountain regions, as a source of warmth. In most poor countries today more than 90 percent of the people depend on firewood as their chief fuel, but all too often, the growth in human population is outpacing the growth of new trees. The resultant firewood scarcity is probably most acute on the densely populated Indian subcontinent and in the semiarid stretches of central Africa fringing the Sahara Desert, although it plagues many other regions as well.

As firewood prices rise, so too does the economic burden on the urban poor. One morning on the outskirts of Katmandu, Nepal's capital city, I watched a steady flow of people—men and women, children and the very old—trudge into the city with heavy loads of

neatly chopped and stacked wood on their backs. I asked my taxi driver how much their loads, for which they had walked several hours into the surrounding hills, would sell for. "Oh wood, a very expensive item!" he exclaimed without hesitation. Wood prices are a primary topic of conversation in Katmandu these days. "That load cost 20 rupees now; two years ago it sold for 6 or 7." Firewood prices have risen even faster than those for kerosene.

Firewood and charcoal prices are climbing throughout most of Asia. Africa, and Latin America. Those who can, pay the price and forego consumption of other essential goods. Wood is simply accepted as a major living expense. In Niamey, Niger, deep in the drought-plagued Sahel of west Africa. the average manual laborer's family is now spending nearly one-fourth of its income on firewood. In Ouagadougou, Upper Volta, the portion is 20 to 30 percent. Those who cannot pay so much hike out into the surrounding countryside to forage, if enough trees are within a reasonable walking distance. Otherwise, they may scrounge for twigs, garbage, or anything else that can be burned.

When I visited the chief conservator of forests in Pakistan's Northwest Frontier Province, he spoke of stopping his car the previous day to prevent a woman from pulling bark off a tree. "I told her that peeling the bark off a tree is just like peeling the skin off a man," he said. Of course the woman stopped, intimidated by her encounter with such a senior civil servant. But no doubt she resumed her practice shortly, for what else, as the chief conservator himself asked, was she to do?

It is not in cities but in rural villages that most firewood is burned and where most people in the affected countries live. The rural, landless poor in parts of India and Pakistan now face a new squeeze on their meager incomes. In the past they have generally been able to gather wood among the trees scattered through the surrounding farmlands, but as wood prices in the towns rise, landlords naturally see an advan-

In regions where firewood is scarce, such as Rajasthan in India, dried cow dung is used as cooking fuel. This practice robs farmland of badly needed nutrients and organic matter.



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tage in carting available timber into the nearest town for sale, rather than allowing the local laborers to gather it for free. While this commercialization of firewood raises the hope that entrepreneurs will see the advantage in planting trees to develop a sustainable, profitable business, thus far, depleted woodlands have been the main result. And the rural poor, with little or no cash to spare, are in deep trouble in either

With the farmland trees and the scrubby woodlands of unfarmed areas depleted by these pressures, both the needy and the entrepreneurs are forced to poach for firewood in the legally protected, ecologically essential national forest reserves. The gravity of the poaching problem in India is reflected in the formation of special guard squads to capture offenders and mobile courts to try them. But law enforcement measures have little effectiveness in such an untenable situation. Acute firewood scarcity has undermined administrative control even in China where, writes S.D. Richardson in Forestry in Communist China, trees on commune plantations are sometimes uprooted for fuel as soon as they are planted.

Trees are becoming scarce in the most unlikely places. In some of the most remote villages in the world, deep in the once heavily forested foothills of Nepal, journeying out to gather firewood and animal fodder is now an entire day's task; just one generation ago the same expedition required no more than an hour or two.

The firewood crisis has not provoked much world attention because those directly suffering its consequences are largely illiterate and wood shortages lack the photogenic visibility of famine. In a way, there is little point in calling this a world problem, for fuelwood scarcity, unlike a shortage of oil, is always localized in its apparent dimensions. To say that firewood is scarce in Mali or Nepal is of no immediate consequence to the Boy Scout building a campfire in Pennsylvania, whereas his parents have learned that decisions made in Saudi Arabia can keep the family car in the garage.

Unfortunately, however, the consequences of firewood scarcity are seldom limited to the economic burden placed on the poor of a particular locality. The accelerating destruction of forests throughout Africa, Asia, and Latin America, caused in part by fuel gathering, lies at the heart of what will likely be the most profound ecological challenge of the late twentieth cen-







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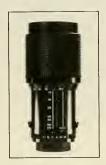
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tury—the undermining of the land's productivity through declining soil fertility, soil erosion, increasingly severe flooding, and creeping deserts.

The Dust Bowl years of the 1930s showed Americans in the plains states the perils of devegetating a region that is prone to droughts. In *The Grapes of Wrath* John Steinbeck described the human dislocation wrought by that interaction of land, climate, and humans; his images could be applied today to large semiarid stretches of Africa along the northern and southern edges of the Sahara, and around the huge Rajasthan desert area in northwest India.

Oversized herds of cattle, goats, and sheep are the chief destroyers of grasslands, but firewood gathering is the principal exterminator of trees in these regions. The caravans that bring this precious resource into urban areas like Niamey are contributing to the southward encroachment of the Sahara itself and, more importantly, to the creation of desertlike conditions in a wide band

below the desert's edge. Virtually all the trees within forty miles of Ouagadougou have been consumed as fuel by the city's inhabitants, and the circle of land stripped for firewood—without replanting—is continually expanding.

Once land in these areas is denuded, topsoil starts blowing in the wind. Sorely needed rainfall quickly runs off the bare landscape rather than soaking in; then, when the predictable drought arrives, a man-made desert has been created.

On the Indian subcontinent, probably the most pernicious single result of

Young Colombian wood gatherer. Children carrying wood are common in developing nations, where more than 90 percent of the people depend on firewood as their chief fuel.



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firewood scarcity is, not the destruction of tree cover itself, but the alternative-the burning of cow dung-to which many people in India, Pakistan, and Bangladesh have been forced. In many areas, hand-molded dung patties have been the only source of fuel for generations, but now their use is spreading. Annually, between 60 and 80 million tons of dried dung, which represents 300 to 400 million tons of wet, freshly collected manure, are burned for fuel in India alone, robbing farmland of badly needed nutrients and organic matter. The plant nutrients wasted annually in this fashion equal more than a third of India's chemical fertilizer use. Looking only at this direct economic cost, one can easily see why India's National Commission on Agriculture recently declared that "the use of cow dung as a source of noncommercial fuel is virtually a crime." Dung is also used for fuel in the Sahel, Ethiopia, Iraq, and in the nearly treeless Andean valleys and slopes of Bolivia and Peru, where in some areas llama dung has been the chief fuel since the days of the Incas.

Even more important than the loss of plant nutrients is the damage done to the soil quality through the failure to return manure to the fields. Organic matter helps preserve a porous soil structure, which absorbs and holds water. Otherwise, the soil may become compacted and water will run off its surface, causing erosion. Water that flows away is also lost for later plant use. Thus, the crops of farmers in the American Great Plains who had applied manure to their fields tended to survive the 1974 drought in far better shape than the crops of farmers who had relied solely on chemical fertilizers.

Progressive deforestation of the steep Himalayan slopes is bringing with it a set of special problems. Nepal is best known to outsiders as the home of Mount Everest. But perhaps the chief distinction of this land, with its beautiful, romantic façade, is that it has the world's most acute soil erosion problem. Ground-holding trees are disappearing rapidly as population growth forces farmers onto slopes too steep for sustained farming, even with astonishingly elaborate terracing, and as villagers roam long distances to collect fuel and animal fodder. Once procuring wood takes too long to be worth the trouble, some farmers begin to burn cow dung, which in the past was applied with great care to the fields. As this departure from tradition spreads, the fertility of the hills, already declining due to soil erosion, will fall even more sharply.

Although most dramatically apparent in Nepal, this same cluster of problems threatens the future habitability of the entire stretch of Himalayan foothills, from Afghanistan through northern Pakistan, India, and Nepal to Burma. And the consequences by no means stop at the base of the hills. When soil washes away, it must relocate somewhere, and the rising load of silt carried by Asian rivers is choking up expensive reservoirs and irrigation works. Pakistan's first major reservoir, the Mangla, was completed in 1967 at a cost of nearly \$600 million. It was expected to have a useful life of 100 years or more, but recent sediment measurements indicate that nearly all its water-holding capacity will be gone in 55 to 75 years.

Perhaps most threatening to the Indian subcontinent's food production prospects-and hence the world's, for nearly one in five human beings lives on the subcontinent-is a rise in the frequency and severity of flooding in Pakistan, India, and possibly Bangladesh. Denuded watersheds, off which rainfall rushes, rather than seeping downward, and the excessive load of upstream sediment, which builds up riverbeds and reduces their capacity to channel water, are exacerbating an already severe flood problem. Major destructive floods in all three countries in the past few years have contributed to the acute food shortages the subcontinent has experienced since 1972.

Firewood scarcity, then, is intimately linked in two ways to the food problems facing many countries. Deforestation and the diversion of manure to use as fuel are sabotaging the land's ability to produce food. Meanwhile, as one Indian official put it, "Even if we somehow grow enough food for our people in the year 2000, how in the world will they cook it?"

In some ways the firewood crisis is more intractable than the energy crisis of the industrialized world. Resource scarcity can usually be attacked from either end-through conservation of demand or expansion of supply. While the world contraction in demand for oil in 1974 and early 1975 has temporarily eased the oil shortage, the firewood needs of the developing countries cannot be massively reduced in this fashion. The energy system of the truly poor contains no fat so easily trimmed as four- to five-thousand-pound private automobiles. Furthermore, a global recession, which has temporar-



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Fuel Wood Consumption in Tanzania, The Gambia, and Thailand

Country	Fuel Wood Consumption Per Capita	Fuel Wood as Share of Total Timber Consumption	Fuel Wood Users as Share of Total Population
Tanzania	1.8 tons/year	96%	99%
The Gambia	1.2	94	99
Thailand	1.1	76	97

From Keith Openshaw, New Scientist, 31 January 1974.

ily dampened the demand for oil, does little to ease the need for firewood. Unfortunately, the amount of wood needed by a particular country is almost completely determined by the number of people who need to burn it. Firewood scarcity will undoubtedly influence the urgency with which governments address the population problem in the years ahead.

Even if there is quick progress on the population front, the demand for such basic resources as firewood will still push many countries to their limits. Fortunately, trees, unlike oil, are a renewable resource. The logical immediate response to the firewood shortage is to plant more trees—on plantations, on farms, along roads, in shelter belts, and on unused land throughout the rural areas of the poor countries. Fast-growing trees, such as some eucalyptus and pine species, can be culled for firewood within a decade of planting.

The concept is simple, but its implementation is not. Governments in nearly all the wood-short countries have had tree-planting programs for some time, but these have been plagued from the beginning. One problem is the sheer magnitude of the need for wood and the scale of the growth in demand. Population growth, which accelerated rapidly in the fifties and sixties, has outstripped the moderate tree-planting efforts of several countries.

The problem of scale is closely linked to a second major obstacle: political priorities and time scales. What with elections to win, wars to fight, dams to build, and hungry mouths to feed, politicians are not likely to concentrate funds and attention on a problem so diffuse and seemingly long-term in nature.

Even when the political will is there and the funds are allocated, the implementation of a large-scale reforestation campaign is surprisingly complex. Planting millions of trees and successfully nurturing them to maturity almost

always becomes enmeshed in the political, cultural, and administrative tangles of a rural locality; tree-planting projects touch upon, and are influenced by, the daily living habits of many people, and they frequently end in failure. The same regions that have too few trees, for example, also have too many cattle, sheep, and goats. The leaves of a young sapling present an appetizing temptation to a foraging animal; thus, marauding livestock are prime destroyers of tree-planting projects throughout the developing world.

Village politics can undermine a program as well. An incident from Ethiopia a few years back presents an extreme case, but its lesson is plain. A rural reforestation program was initiated as a public works scheme to help control erosion and supply local wood needs. The planting jobs were given to the local poor, mostly landless laborers who badly needed the wages-albeit low-they could earn in the planting program. Seedlings were distributed, planting commenced, and all seemed to be going well. Then the overseers journeyed out to check the progress. They found that in many areas the seedlings were being planted upside down. The laborers, of course, knew the difference between roots and branches, but they also knew that, given the feudal land-tenure system in which they were living, nearly all the benefits of the planting would flow into the hands of the landlords.

In country after country, the same lesson has been learned: tree-planting programs are most successful when a majority of the local people are involved in planning and implementation and clearly perceive their self-interest in success. Central or state governments can provide the initial stimulus, technical advice, and financial assistance, but unless community members understand why land to which they traditionally have had free access for grazing and wood gathering is being demar-

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cated into a plantation, they are apt to view the project with suspicion and hostility. With wider community control, however, such felt needs as grazing rights can be built into the program from the beginning, and a motivated community will protect its own project and provide labor at little or no cost.

Just such an approach—working through village councils, with locally mobilized labor doing the planting and protection work—is now being tried in India. This approach too has its pitfalls; Indian villages are notoriously faction ridden, and the ideal of the entire community working together for its own long-term benefit may be somewhat Utopian. But if it can get under way on a large scale, the national program in India may succeed. Given a chance, fast-growing trees quickly bring visible benefits. The Chinese have long used a decentralized, community-mobilization approach to reforestation, apparently with moderate success.

Whatever the success of tree-planting projects, a wider substitution of alternative energy sources would contribute greatly to solving the firewood problem. A shift from wood-burning stoves to those running on natural gas, coal, or electricity has indeed been the dominant global trend in the last century and a half. As recently as 1850, wood met 91 percent of the fuel needs of the United States, but today, as in the other economically advanced countries, mainly the scattered poor in the mountains and the intentionally rustic chop wood out of necessity.

In the poor countries, too, the proportion of wood users has fallen gradually. But the hopes of foresters and ecologists for a rapid reduction of pressures on retreating woodlands through a faster shift to kerosene—usually the most feasible firewood substitutewithered overnight when, in December, 1973, OPEC announced its new oil prices. The price of bottled gas, another common firewood substitute in poor countries, has also multiplied.

Fossil fuels are not the only alternative energy source being contemplated, and over the long term many of those using firewood, like everyone else, will have to turn to other sources. Nothing, for example, would be better than an inexpensive device for cooking dinner in the evening with solar energy collected earlier in the day. For decades Indian scientists have experimented with a device that breaks down manure and other organic waste into methane gas, which could be used for cooking, and a rich compost for the farm. More

than eight thousand of these bio-gas plants, as they are called, are now being used in India. Without a substantial reduction in cost, however, they will only slowly infiltrate the hundreds of thousands of rural villages where the fuel problem is growing to a crisis level.

The firewood crisis, like many other resource problems, is forcing governments and analysts back to the basics of man's relationship to the land-back to concerns lost sight of in an age of macroeconomic models and technological optimism. The attitude of people toward trees is being brought into sharp focus. In his essay "Buddhist Economics," E. F. Schumacher praises the practical as well as esoteric wisdom in the Buddha's teaching that his followers should plant and nurse a tree every few years. Unfortunately, this ethical heritage has been largely lost, even in the predominantly Buddhist societies of Southeast Asia. In fact, most societies today lack an ethic of environmental cooperation, an ethic not of conservation for its own sake, but of human survival amid ecological systems heading toward collapse.

This will have to change-and quickly. The inexorably growing demand for firewood, as well as the spread of forest clearing for agriculture, calls for tree-planting efforts on a scale more massive than most bureaucrats have ever contemplated. The suicidal deforestation of Africa, Asia, and Latin America must somehow be slowed and reversed. Deteriorating ecological systems have a logic of their own; the damage often builds quietly and unseen for many years, until one day the system collapses with a lethal vengeance. Ask anyone who lived in Oklahoma in 1934—or Chad in 1975.

B. B. Vohra, a senior Indian agricultural official who has pushed his government ahead on numerous ecological causes, shakes his head and watches New Delhi through his office window. "I'm afraid that we are approaching the point of no return with our resource base. If we can't soon build some dramatic momentum in our reforestation and soil conservation programs, we'll find ourselves in a downward spiral with a momentum of its own.'

Without a rapid reversal of prevailing trends, in fact, India will find itself with a billion people to support and a countryside that is little more than a moonscape. But politicians in India and other poor countries will soon take notice, for they will realize that if people cannot find firewood, they will surely find something else to burn.

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Diversity Through Time

Is the "evolutionary play" a story of progress?

As this father of a five-year-old child knows only too well, the easiest and most obvious questions to ask are often the hardest to answer. (Jesse and I have recently been struggling with "dust and gas" as the original source of the earth and "chemicals in the ocean" that made life and eventually man. "But what people pumped the gas, Daddy?" Divinity certainly does have its uses.)

When surveying the history of life, paleontologists have always sought signs of a progressive order in what G.E. Hutchinson called the "evolutionary play." The major attributes of life are form and diversity. In form, we have argued for a progression in complexity and intelligence leading to us. (I have already criticized this anthropocentric imposition upon life in my June-July, 1974, column.) In diversity, we have sought primarily to illustrate an increase in the total number of species through time-the more-is-better thesis as illustrated in Robert Louis Stevenson's couplet:

> The world is so full of a number of things, I'm sure we should all be as happy as kings

Thus, my obvious (but difficult) question: Has the diversity of life increased through time? The path to an answer would seem to be straightforward, if somewhat laborious. We may define diversity simply as the number of species living at any given time. People have been describing fossil species for 200 years, so we can

simply get out the literature on the fossil record and count.

Before presenting the results of such a count, I must enter three disclaimers:

- 1. I shall follow the usual parochialism of invertebrate paleontologists in considering only shallow-water marine invertebrates. Indeed, these constitute most of our fossil record. Land vertebrates may arouse our immediate interest, but their appearance in the record is rare and spotty in comparison. Of deepwater life, we know almost nothing—the appropriate sediments simply do not end up on continents where we can study them.
- 2. At one level, the answer to my question is a trivial "yes"-and I shall ignore this. Assuming, as most scientists do, that life had its origin in one or a very few forms (descended from those infernal chemicals of my first paragraph), then the 750,000 species of modern insects surely represent an increase. But we cannot go back to the very beginning. Most of our modern phyla appeared about 600 million years ago in an explosive burst of evolutionary activity (see my column of November, 1974). Thus, my question becomes: Has the diversity of life been increasing since this relatively more recent establishment of its basic forms?
- 3. Unfortunately, we cannot count species. The literature is too vast and unorganized and, especially, inconsistent. Before the infusion of modern evolutionary theory into paleontological practice during the past twenty-five years, paleontologists customarily gave a new species name to any animal bearing a peculiar and rec-

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ognizable feature. We shall have to count the more consistent and stable higher taxa (genera or families) and make an estimate of species from these tabulations.

James W. Valentine of the University of California at Davis has made such a count for families of wellskeletonized, shallow-water, bottomdwelling invertebrates. Diversity rose rapidly following the Cambrian evolutionary explosion of 600 million years ago, remained fairly constant for a while, crashed spectacularly with the great mass extinction of the late Permian (see my column of October, 1974), and has been comfortably on the rise ever since. The general trend is up. This rise is much more striking for the estimate of species that Valentine derives from his graph for families. He examined the families most responsible for the post-Permian upturn and found that their genera increased at an even greater rate. Assuming that species will increase even faster than genera, Valentine finds a simply spectacular rise in post-Permian times, with the modern fauna containing fully ten to twenty times the total number of species inhabiting Paleozoic seas before the Permian crash.

If Valentine is right, what could be causing this increase in numbers of species? I can imagine three possible general reasons:

- 1. It arises from a change in the boundary conditions of the physical environment for life. There is, for example, a strong relationship between the number of species and habitable area (see my column of October, 1974). If the area of shallow seas has been increasing since the Permian, then the record of species diversity may be an indication of the earth's physical history.
- 2. It is intrinsic to the evolution of species in an ecosystem. In a view held by many biologists, the ecological niche of a species can be subdivided almost indefinitely by the increasing specialization of the original species and the evolution of new species to fulfill other functions once assumed by a broad-niched ancestor. Thus, diversity has no intrinsic limit it is held in check mainly by the occasional "environmental zaps" that cause mass extinctions and reset the evolutionary clock.
- 3. It is a result of the increasing morphological diversity and complexity of life. Bursts of speciation occur when new "inventions" enable

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Time is running out for Kirtland's warbler. Despite heroic efforts by devoted admirers, its numbers are shrinking. Read on about how you can help and — at the same time — make a very interesting investment.

irtland's warbler has never existed in large numbers. From May 13, 1851, when Dr. Jared P. Kirtland first discovered the bird on his farm near Cleveland, its population has rarely exceeded 1,000. A drop in the bucket compared to the hundreds of thousands of some species of the wood warbler family. Or, as one admirer puts it, "If you weighed all the Kirtland's warblers in existence, they'd just tip 10 pounds."

And yet, for 10 pounds of beauty, grace, and song, the devotees of this endangered warbler have gone to extraordinary lengths to prevent its extinction. Elaborate traps have been specially designed and constructed around its range to catch the cowbird—a parasite which reduces the number of Kirtland's warblers by 78 percent. Forests of young jack pine—its only natural habitat—have been created expressly for it. Areas that have burned accidentally have been reserved for it. And forests of jack pine have even been burned by plan to create new growths of the vital tree.

Despite this extraordinary nurturing, Kirtland's warbler continues to dwindle. This elusive species which winters on a Bahama island, has been reduced in its summer range to eight colonies found only in three counties in Michigan. In the last 13 years, its numbers have shrunk by two-thirds, Only 334 adult birds were counted in the last census. Help is urgently needed.

Kirtland's warbler is only one of 114 species and sub-species of wildlife in the United States now threatened with extinction. Foremost among the private non-profit agencies devoted to the protection of these and all forms of wildlife is the National Audubon Society. It maintains 44 sanctuaries throughout the country to provide safe nesting, feeding and resting sites for birds, and a protected environment for other wildlife. Jean Dorst, the great European environmental scientist has said, "The National Audubon Society... has done more to protect nature 4han any

In search of perfection

other private group in the world."

Some 300 years ago in England it was discovered that the addition of lead monoxide produced glass of extreme brilliance and



KIRTLAND'S WARBLER, second in a series of eight 101/2" plates mouth-blown of Bavarian lead crystal. Designe by Albert Earl Gilbert, each plate is copperwheel engraved, numbered, and signed. Edition limited to 5,000

great weight. It was called crystal. When struck, it rang like a bell. Indeed, the first strike signalled the rise of a new art form.

The most artistically significant method of decoration developed was copperwheel engraving. In this highly demanding discipline, a master engraver interprets the artists' designs in intaglio by applying the crystal object to a small high-speed copper wheel anointed with oil and emery powder. He may use as many as 50 different wheels ranging from ½ inch to 4 inches in diameter to complete one engraving. The fate of every piece is entirely in his hands. One false move against the wheel condemns to the scrap heap what might otherwise have been a masterpiece.

Perfection in this intricate art is rare at best. Many attempts will be made before 5,000 fine crystal plates will meet the standards of excellence necessary to be numbered as a Kirtland's Warbler Plate in the Audubon Collection. Numbers will be assigned in the sequence in which orders are received. The

subscription price is \$198 postpaid. Becaus the hand production is very slow and pain: taking, orders are limited to one per subscribe

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living forms to fill previously unoccupied ecospace. Insects, for example, inherited an empty atmosphere and radiated spectacularly in a profusion of small, winged forms.

These potential causes imply very different evolutionary theories. In reasons 2 and 3, increasing diversity is built into the evolutionary process-it is a necessary consequence of the passage of time, provided no unusual circumstances intervene. A radical alternative views the world as a long-term, relatively stable equilibrium. The ecospace has a limited set of potential niches that exist independent of organisms that might inhabit them. When complex life evolved some 600 million years ago, these niches were quickly filled. Subsequent evolution merely shuffles the cards and permits a one-for-one replacement. Designs are set, roles are filled, and evolution becomes an endless parade of variations on basic (and ancient) themes. In its barest form, equilibrium theory stands in striking conflict with our traditional view of directional trends (usually improvements) in the history of life. An increase in diversity due to reason 1 is not inconsistent with equilibrium notions. If more space is made available or if the same space is divided into isolated packages, then the equilibrium number of species is raised by an external change in boundary conditions of the physical world.

Before examining the merits of our three reasons, we must inquire whether there is any phenomenon to be explained. Could Valentine's estimate of diversity be an artifact of our woefully incomplete fossil record? I hate to reveal my profession's trade secret, but our fossil record is a pitiful fragment of past life. Many groups of organisms have no hard parts and, hence, are not preserved at all (these are discounted in Valentine's estimate); certain times and environments are poorly represented; even the vast majority of hard parts never enter the record-they are broken up before burial or obliterated afterward dissolution, recrystallization, metamorphism, and so on. Unfortunately for Valentine, these biases might easily mimic his findings-the further back we go in time, the harder it is to preserve a species. Older rocks are rarer than younger ones, and they are more often altered in ways that destroy the fossils they once contained. Valentine's increasing diversity, then, might simply be an artifact of the fossil record's improvement through time.

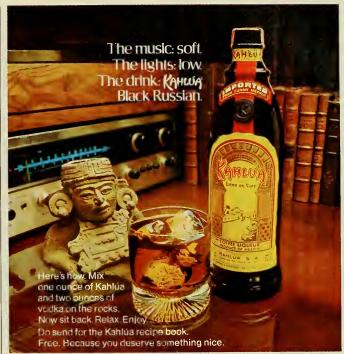
David M. Raup of the University of Rochester has recently made just such a claim. He proposed a hypothetical "true" estimate in which diversity rises rapidly from the Cambrian explosion to a mid-Paleozoic peak. It then declines slowly to a somewhat lower level by the end of the Permian and remains constant thereafter-there is no Permian "crisis" and no post-Permian increase in diversity. Raup then estimates the effect of biases that yield apparently increasing diversity for artificial reasons. Applying these biases to his hypothetical estimate, he constructs a fossil record with all the features of Valentine's graph. Cynics among you may question the validity of any profession in which two leading members can maintain such disparate, yet plausible, views. So be it. In any case, if Raup is right (or even largely right), the equilibrium view obtains powerful support.

As a typically indecisive academic liberal, I will state my bias in favor of an intermediate view. I believe that species diversity has increased but not nearly as much as Valentine proposes. And, as a general adherent to equilibrium thinking, I imagine that this increase is due largely to my first reason-changes in the physical environment for life.

What then is the evidence for my three potential reasons for the appar-

ent increase in diversity?

In support of my first reason, the history of continental drift accords well with changes in diversity estimated by Valentine. Almost all shallow seas are associated with the peripheries of continents. When the continents are together in a single supercontinent, Pangaea, the area of shallow seas is at a minimum. As continents break up and separate, two things favor increasing organic diversity. First of all, shallow seas increase (there is more area around many small pieces than around a single big piece). Secondly, the small pieces become isolated from each other and diversity increases due to provincialism. There may be, as equilibrium theory demands, the same kinds of niches around two small pieces, but if the pieces are completely isolated, different species may evolve to fill the same niche in two places. If the pieces come together, a single species may fill the niche over the enlarged area.



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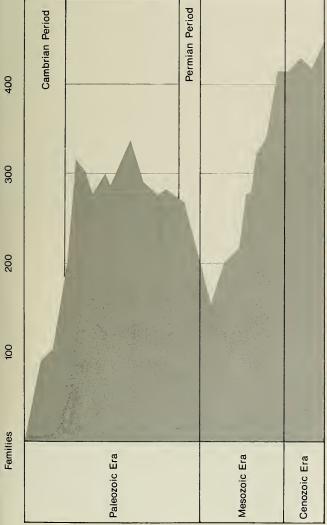


Continents were somewhat separated during the early Paleozoic, following the Cambrian explosion of life. They slowly drifted together during the Paleozoic, forming Pangaea by the end of the Permian. Subsequently, Pangaea broke up and its

The number of well-skeletonized, shallow-water families of marine invertebrates has varied through time from the Cambrian explosion to the present.

pieces have been separating ever since. Provincialism is at its highest now and increasing diversity may reflect nothing more than this progressive isolation of faunas. The timing of changes in Valentine's estimate of families is almost a record of changes in continental positions—moderately high diversity for moderately separated Paleozoic continents, a faunal crash for Pangaea, and since then, an increasing diversity with increased separation.

I know of no evidence to support my second possible reason, which explains the increase of diversity in terms of successive niche partitioning



After J W Valentine, Journal of Paleontology, 197



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due to organic specialization. In fact, several theoretical ecologists, led by Robert May and the late Robert MacArthur of Princeton University, have been developing a theory of "limiting similarity" for the subdivision of ecological niches. There is a limit to how similar two organisms can become in their ecological roles and utilization of resources before they are unable to coexist in the same area. There is thus a limit to the subdivision of niches.

My second reason can operate only if competing species in ancient faunas were characteristically far from limiting similarity. Yet there is no evidence to indicate that the average difference between competing species has decreased steadily over hundreds of millions of years; in fact new competitors quickly attain limiting similarity in modern ecosystems.

Do morphological "inventions," my third reason, allow an increase in diversity? The increasing diversity of several invertebrate groups has been plausibly linked with their acquisition and exploitation of new ecospace. Steven M. Stanley of Johns Hopkins University has argued that the striking increase in species of clams through time can be linked with two major inventions: fusion of the mantle around their soft parts, which protects them and forms a hydraulic system for efficient burrowing, and byssal attachment to hard substrates, which allows the invasion of rocky surface environments. The original clams were imperfect, shallow burrowers. These inventions allowed them to capture ecospace in two directions-by deep burrowing and by attaching to rocky surfaces. Yet, although clams increased in diversity, we have no reason to assume that life in general became more abundant. The clams may simply have wiped out some previous occupants of deep sediments and rocky surfaces.

Notions of equilibrium and intrinsic increase of diversity form two extreme metaphors for the history of life. The truth, as Aristotle said, must lie between them at the aurea mediocritas—the "golden mean." Nonetheless, I believe that the equilibrium view is worth our special consideration, if only because it challenges so strongly our bias toward the progressive view of life and its equation of evolution with advancement.

Stephen Jay Gould teaches geology at Harvard University.





Down East Mice

by Kenneth L. Crowell

"We must not underestimate what a mouse can do, given sufficient time for the improbable to occur"

Scattered along the coast of Maine are thousands of islands—hilltops marooned by rising sea levels after the last Ice Age. From a vantage point on one such island in Penobscot Bay, I can see the spruce trees of the next island, a scant half mile away through the lifting veils of morning fog. This island is a granite knob, ringed with a bold ledge. Gulls feed in seaweed exposed by the ten-foot tide; an osprey wheels and cries overhead.

Most of the four-acre island is covered with white spruce and balsam fir, but at its western end, there is a small clearing where sheep grazed as recently as a few decades ago. The thick and matted grasses of this swale

are riddled with a network of narrow passages: some open to the sky above; others with roofs of fallen grass. The floors of these passages are marked with neat piles of fecal droppings and miniature haystacks.

A brown form streaks by; another emerges from a tunnel and scuttles across an open stretch of runway. They are meadow voles, or field mice, Microtus pennsylvanicus, the most common mouse species in North America. One of the creatures stops, reaches up for a stem of grass, and deftly nips it off. Sliding the stem between its paws it nibbles the succulent portion at the node, nipping off and discarding the tough parts to form yet another hay pile.

Every few years, when the cyclic mouse populations reach peak levels, this island meadow looks as if it had been cut with a scythe. As many as a hundred mice per acre scamper through the passages, and the vegetation comes alive with the sounds of their encounters. When two mice meet in a tunnel, they rear up like tiny bears, make sparring motions with their paws, and bare their yellow incisors. They reinforce their threatening gestures with emphatic squeaks, before dropping down and scurrying off in opposite directions.

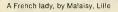
Each male and his associated females occupy a system of protective runways and subsist largely on a diet of grass stems and seed heads, supplemented by a variety of other plants, insects, and berries. In turn, field mice serve as food for many carnivorous mammals, hawks, and owls. But here on the islands there seem to be no predators that regularly feed on tiny rodents. A pile of mink droppings under a mossy bank or a



Despite the presence of large populations of field mice, red-backed voles are able to survive on some Maine islands by occupying forests and glades.

Dave's Island, typical of those in Penobscot Bay, is inhabited by only one mouse species—the field mouse. Other species cannot compete in the restricted habitat.







A Swedish child, by Brorson, Malmö



Sister and brother, by Gilbert, Toronto

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crow pellet regurgitated on a sunbaked ledge usually consists of crumbling fish vertebrae and crab shells and only rarely reveals mouse fur.

On another part of the island, a granite basin of rainwater reflects wild iris, and the few rays of summer sun sift down through the spruces, highlighting the greenish gray oldman's-beard lichen that hangs from the ever damp branches. The surrounding sphagnum moss and wild cranberry bog, like the meadow, is also laced with mouse runways. The tunnels thread through a raspberry thicket and into the dark forest. One follows a fallen branch and goes through a clump of ferns, indicating that the field mouse is also at home in the woods.

I have found field mice occupying almost all habitats and even the smallest islands. Usually the only small mammal present, they exemplify three characteristics of insular faunas: (1) fewer species inhabit islands than comparable mainland areas, (2) those species that are present are often extremely abundant, and (3) they occupy a broader range of habitats—apparently invading the niches of the "missing" species.

The species that are missing from the small islands are two other members of the *Cricetidae* family, the redbacked vole and the deer mouse. Both of these species inhabit the woods of Deer Island, one of the larger islands of the Maine coast.

The red-backed vole, Clethrionomys gapperi, has the same short ears and tail as its relative, the field mouse. As its name suggests, the fur on its back is a rich rusty red. It is a close competitor of the field mouse, and the two species are normally not found in the same habitat. Redbacked voles prefer ferny wooded glades, from which they usually exclude the field mice.

The other species, the deer mouse, Peromyscus maniculatus, is readily identified by its large, delicate ears, big eyes, and long, silky tail. Unlike field mice and red-backed voles, which are active throughout the day, the large-eyed deer mice are nocturnal. Their long tails aid their balance as they run along darkened highways of fallen spruces. Deer mice, like redbacked voles, eat insects and depend more on fruits and seeds than do field mice, which eat the vegetative parts of plants. Deer mice are commonly found in homes and camps, but are not to be confused with the alien house mouse, Mus musculus, of more urban areas.

Even though the habitat of the small islands would seem to favor the deer mouse and the red-backed vole, these species are absent. The question of why this is so can be viewed in the context of one of the fundamental questions of ecology: What determines the number of species living together in a natural community?

Using a dozen islands as natural laboratories, I began in 1962 to introduce the two missing species. Because only a few very small islands were chosen and I was simply giving native species a boat ride across a half mile of water from Deer Island, I was confident that no untoward ecological disturbance would result. Surprisingly, I found that although a single pair of deer mice succeeded in establishing populations, it took six to eight pairs of red-backed voles to initiate new populations. But once established, it was clear that both species could survive and reproduce on the islands.

In order to study the growing populations, I surveyed the islands into grids and placed live traps every fifty feet. Captured animals were marked with small, numbered ear tags for recording survival rates, individual movements, and reproductive states. From weekly changes in the proportion of marked to unmarked animals captured, I was able to estimate the population size and ascertain habitat preferences.

During the first two years, both the deer mice and the red-backed voles increased rapidly on the research islands, reaching densities of more than twenty mice per acre on some islands. Densities on the mainland, in contrast, averaged only four mice per acre. Whereas deer mice occupied all habitats, including meadows, redbacked voles seldom ventured beyond the canopy of spruces. The red-backed voles, moreover, enjoyed only brief success-within five years all experimental populations of these mice had died off. Although the deer mice became extinct on the three smallest islands, other populations have persisted for fourteen years. Over this period, the field mice became extinct on at least three islands. but were able to recolonize without the aid of humans.

Continued success requires either a high immigration rate or a low rate of extinction or, sometimes, both. The ability of the three species to establish and maintain populations on islands varies widely. First, a prospective colonizer must reach the islands. Ten thousand years ago, after the glaciers receded from the coast, but before those of the north melted and added their water to the seas, the sea level was about 180 feet lower than at present, and all the bays were dry. The Maine islands were possibly colonized by means of postglacial land bridges, and the animals could have been there ever since. But certain observations cannot be reconciled with this one-time-colonization hypothesis.

It does not explain why deer mice are found on large outlying islands but not on the smaller intervening ones. Moreover, if field mouse populations undergo periodic extinctions, the presence of field mice on these islands cannot be accounted for by a single past event. We must look for continuing processes.

Deer are occasionally seen swimming between the islands. This feat may seem too much to expect of a mouse, yet field mice have been found to swim up to half a mile between islands in the frigid waters off Newfoundland. I have caught deer mice, however, only on those small islands that are connected to Deer Island at low tide, indicating that although this species ventures into the intertidal zone, it does not readily cross open water.

Ice provides an alternate route for dispersal. The bays in Maine freeze over periodically, and I have found field mouse tunnels extending onto the ice from adjacent shore vegetation. A mouse might be able to make the crossing, provided it did not get picked up by a snowy owl. Mice could also be cast adrift as ice floes are carried out to sea by the rising tide. That common hibernators such as chipmunks and skunks are uniformly absent from even the larger islands suggests that winter crossings are of major importance, since this route is available only to species that are not hibernating when ice forms.

An entire mouse litter occupying a hollow log could easily be transported by winds and tides. As unlikely as this seems, the fact that small vertebrates have reached oceanic islands throughout the world attests to the efficacy of such a chancy process, one which evolutionist George Gaylord Simpson has aptly called "the sweepstakes route." We must not underestimate what a mouse

can do, given sufficient time for the improbable to occur.

Another means of transport is man. Indians visited the islands for thousands of summers. Anyone who has had the not uncommon experience of discovering a nest of deer mice in a seldom-used teapot or boot realizes the possibility of human transport. Yet it is the field mouse we find on so many of the islands, not the deer mouse.

Upon reaching an island, colonists must rapidly establish a population. For this task the field mouse is admirably suited. One of the most prolific rodents, it can produce a litter of six to eight young every two weeks, and offspring are sexually mature within one month. Based on the rate of increase of Maine island populations, one field mouse could give rise to 233 descendants in a year, while a typical red-backed vole would leave only 25.

To avoid extinction an established species must be able to maintain its population. Predators, parasites, and

Principally a nocturnal species, the deer mouse occupies all island habitats but requires more space than do the two other mouse species.

disease all take their toll, but only when such stresses coincide does extinction threaten. Like colonization, extinction is a capricious process. Whatever the causes of individual mortality, two factors are important for survival of the population: size and stability.

Because of their smaller home ranges, field mice attain greater densities than do deer mice or red-backed voles. But the very attributes that aid them in founding a population eventually become a liability. Unable to control their high rate of increase, field mice periodically outstrip the carrying capacity of the environment. Starvation, disease, and social competition cause the population to crash. During such periods populations are prone to extinction.

The population density of deer mice, however, is regulated by compensatory changes in birth and death rates. As the experimental populations grew, the pregnancy rate dropped markedly, and the chance of an individual surviving its second year of life was reduced by 25 percent. Because deer mice have large home ranges, a stable population requires an island of at least one square mile. Fluctuating amounts of seeds and fruits may cause extinctions on small islands, but on a large island a few individuals usually remain, providing a nucleus that allows the population to survive. In this demographic contest, the deer mouse is the tortoise and the field mouse, the hare.

The red-backed vole comes out a poor third on all fronts. It does not regulate its numbers effectively, and its rigid habitat requirements limit its population to only certain parts of an island. The same year in which the last two introduced populations of red-backed voles disappeared, their numbers were extremely low on both Deer Island and the nearby mainland. Such regional synchrony between population levels was not observed in the other mouse species, suggesting that the red-backed vole is especially vulnerable to fluctuations in environmental conditions and attendant effects on food supplies.

Dispersive abilities and population dynamics, rather than random colonizations, clearly dictate which species inhabit the islands and explain why the field mouse is found on all the islands. This mouse species, like a weed species, inhabits the early stages of plant succession in a changing landscape. It produces large numbers of young, which seek out new habitats. The same characteristics that adapt it to the role of an opportunist on the mainland enable it to colonize a great variety of islands.

Studies of these island mouse populations thus provide a model for understanding distributions of other



Busan A Saltman

species. Looking at other mammals of the offshore islands, we find a close correlation between the area of an island and the number of species present-larger islands have more species. We might suppose that when rising sea levels created the Maine islands, they were more or less equally endowed with species. Extinctions then reduced the number of species in accordance with island areas. Smaller islands lost more species and at a faster rate. Distant islands, isolated sooner and having lower immigration rates, were able to maintain fewer species.

Just such a sequence might have occurred on the islands of the Bering Strait, according to Steven Young, a biologist at the Center for Northern Studies in Wolcott, Vermont. During the Ice Age the Bering land bridge was free of ice and presumably served as a refuge for most common arctic species. Rising sea levels 8,000 years ago produced a chain of islands that today lack all the large ungulates and carnivores, and even such characteristic tundra species as the hare and ptarmigan.

Such effects are not limited to islands as we normally think of them. Any discontinuous habitat, in effect, becomes an island. Caves, mountaintops, and ponds are readily recognized as islands. A single tree, if it is the only one of its kind for several miles in a tropical rain forest, is an

island to some species. We set aside parks and refuges to preserve wilderness. These areashavens from most forms of encroachment-also become islands. And the smaller they are, the faster they lose species. No matter how carefully a reserve's integrity is maintained, species loss is inevitable. The large and the lonely, the rare and the specialized, they are the first to go.

This process is accelerated as opportunistic species invade from the perimeter. Many faunal shifts occur as those species that are more tolerant of human activity are increasingly represented. As skunk and raccoon displace mink and fisher, and as deer replace moose, the likes of the unspecialized and versatile field mouse will come to predominate.

Variety is both the spice and the staff of life. To conserve natural diversity, we must understand the ecological laws on which it depends. Paradoxically, the study of the impoverished fauna of islands can contribute to this understanding.

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Fish in Schools

Togetherness is not only a way of life but also the means of survival for thousands of fish species

Schooling behavior is almost as prevalent as feeding and reproducing among the approximately 20,000 species of fish. About 16,000 species school as juveniles and about 4,000 of those continue to school throughout life. Schooling is found in a

broad range of fish types, from the primitive, fragile anchovy to the advanced, powerful tuna. Schools of herring, cod, striped bass, and others make commercial fisheries feasible. Schooling is not only economically important, but it also provides animal behaviorists with endless puzzles about behavioral mechanisms and adaptive advantages.

Many schools are large, containing thousands of fish, but any number can compose a school—from two

to the millions of individuals found in a seventeen-mile-long spawning run of herring. Schools have no leaders, and fish at the forward edge may suddenly find themselves at the rear when the school reverses direction. School members are usually of the same species and the same approximate size. Smaller fish are not able to maintain the right speed; larger fish swim too far ahead.

The tendency to school is certainly genetically programmed, for it ap-



pears when fish have had little or no experience with each other. Fish can "recognize" their own kind from the very beginning of their lives. For example, Menidia, or silverside, fry, when they are about one-quarter inch long, drift aimlessly with other plankton and are exposed to a variety of vertebrate and invertebrate species, but when they reach one-half inch in length, they come together and form schools. The newly formed schools contain a single species





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For complete rules, write: Alaska Big Game Photo Contest Information-Education Section Alaska Department of Fish and Game Subport Bldg, C Juneau, Alaska 99801 only. This specificity is dramatically demonstrated in laboratory experiments when two related schooling species are mixed. After a brief period of trying one another out through approaches and body vibrations, the young fry separate into two species-specific groups. Clearly, at the very earliest stages, the fish are able to distinguish appropriate peers and are mutually attracted to one another. Indeed, mutual attraction is the primary criterion used for designating true schooling types.

But schools have other characteristics as well. When fish in a school move forward, they polarize, that is, they orient in parallel fashion—all individuals head in the same direction, swim at the same speed, and maintain fairly fixed distances from each other. When a school stops swimming, it depolarizes, but the fish remain together.

Parallel orientation and fish-tofish spacing are distinctive qualities that give a school a characteristic three-dimensional structure—a geometry of its own. Fish in a school swim, not abreast, but in diagonal formation in a staggered pattern. When fish-to-fish spacing and diagonal positions change, the school looks quite different.

The most stunning feature of schooling is displayed when a school turns or changes direction. The fish then appear to be acting synchronously-turning together, increasing speed together, moving always in concert. This concurrent behavior entrances and baffles today's observers just as it mystified the scientists of the late nineteenth century, who postulated the existence of a "group mind" to explain the harmony of thousands of fish acting as one. The group mind concept had a short life, however, and twentiethcentury scientists are discovering the biological mechanisms responsible for the synchrony and characteristic organization of schools.

In the 1920s experimenters identified vision as the sensory modality critical to schooling. Sightless fish do not approach other fish and consequently cannot school. Even though schooling fish must be able to see, they do not need to distinguish much detail for the school to maintain its coherence. A crescent moon, the stars, or phosphorescent organisms that cling to the skin of some species, all give sufficient light to enable schooling to continue. In

one laboratory experiment, a school of jack mackerels maintained cohesion even when the light was so dim that it required ten minutes of adjustment before the observer could see the school. In the total absence of light, schools will disperse. Fish observed in the dark through a "snooperscope," were found to be swimming randomly inside a tank, seemingly unaware of each other's presence.

In addition to the visual sense, which is not only primary but which probably also serves as the major pathway of communication, other senses such as the olfactory and auditory may function in schooling. It is well known that fish have a fine ability to discriminate between even the faintest odors. It seems unlikely, however, that changes in the speed and direction of a school are communicated through a schooling pheromone, a chemical substance that conveys intraspecies information, but olfactory cues may operate in species discrimination, that is, in the recognition of similar types. Communication of changes in speed and direction through the production of sound is also unlikely. Schooling fish tend to be almost noiseless. Several experimenters have found that at night, when visual references are unavailable, some species produce sounds that may serve to keep the group together. These sounds are not detected, however, in the daytime in an actively moving school.

All fishes possess a special sensory system, called the lateral line, that detects changes in the movement and pressure of surrounding water. In many species the lateral line consists of a series of canals crisscrossing the head in a characteristic species-typical pattern. In addition, most fishes have a single canal that courses down the lateral body wall on each side. The basic sensor of the lateral line is the neuromast, a cluster of innervated hair cells capped by a gelatinous sheath known as a cupula. Neuromasts are spaced regularly along the canal. When water is displaced around a fish, the movement is detected by a neuromast through the bending of the cupula. Fish can see changes in the spacing, speed, and direction of schools, but because of the sensitivity of the lateral line system to movements and pressure changes in the surrounding water, it may serve as a prime source of information.

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Exactly how the lateral line functions in schooling remains a mystery, but that it does function is suggested by the following experiments on tuna conducted by Phyllis Cahn, an acoustic physiologist at Long Island University, New York, and on jacks by the author. When jacks were artificially separated from each other by a transparent partition that blocked reception in the lateral line, the fish moved closer together than in a normal school and fish-to-fish spacing was markedly reduced. Tuna, on the other hand, will spread farther apart—from two to four times their normal distance-under similar experimental conditions. The loss of information from water displacements appears to upset the characteristic spacing maintained by schooling fish, and sight alone evidently cannot compensate for the lack of input derived from water movements.

In another experiment, John R. Hunter and Jon Van Olst, of the National Oceanic and Atmospheric Administration (NOAA) at La Jolla, California, showed that spacing and fish length are related. When they are young, jacks, mackerels, silversides, and anchovies swim in loosely structured schools, and the spaces between the fish measure about three to four body lengths. When the fish grow to three or four inches, the spacing shrinks to half a body length for all four species. Spacing of half a body length is also found in other species, which suggests that this may be the optimum distance for obtaining the most precise water displacement information through the lateral line sensors.

A last point about schooling and the senses concerns the relationship between speed of response and the visual system. Hunter found that a jack mackerel reacts more quickly to changes in a neighbor's activities if it sees the neighbor in certain areas of its visual field. By photographing one tethered fish and five freely swimming fish, he determined that the responding fish reacts more quickly to a neighbor's behavioral change if the neighbor is either directly ahead and can be seen with both eyes simultaneously or if the neighbor is at such an angle alongside that its image fills the entire visual field of one of the responder's eyes. The reaction time of the responder fish to changes in direction or speed is a mere 0.15 to 0.20 seconds, hardly more than a blink of an observer's eye. Indeed, the reaction time is so short that, to the unaided eye, an entire school of fish may seem to turn simultaneously in response to a change initiated by only a few individuals. This ability to react quickly is highly useful for survival.

All evidence indicates that it is beneficial for fish to be members of a school. Fish in schools swim for longer periods, cover greater distances, and tolerate colder temperatures than comparable fish swimming alone. Diverse experiments show that groups of schooling fish consume less oxygen per fish than an individual school member swimming alone. Goldfish in a group tolerate higher doses of toxins per fish than when alone, sunfish learn the pathways of a maze more quickly in groups than as singles, and groups of carp avoid a moving net more successfully than loners. An individual fish trained with a group and then removed regresses to poorer scores. The advantages of group life seemingly cannot be maintained by single fish.

From one point of view, schooling might be considered a form of social behavior in which the actions of a few benefit the many. For example, when a predator swoops out of the sky and plunges into a school of prey, the fish in the predator's immediate vicinity, reacting swiftly, alter their swimming course and speed in order to escape. Through visual signals and shifts in the water pattern, these changes are rapidly communicated to other fish in the school. A wave of disturbance will sweep through the school until the whole group diverges from its original path. The total elapsed time is perhaps half a second. In this case, the response of a few has benefited the entire group, and the school has escaped from the predator. A few individuals may have been consumed, but their loss is insignificant to the group.

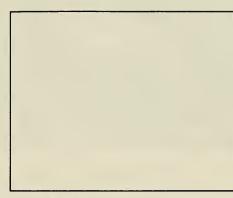
Each member of a school can be thought of as a scanner of its own environment. In a randomly chosen school there may be hundreds, thousands, or even millions of scanners. Fish at the edges of the school become the "eyes" of the fish in the center, thereby enabling any fish to "see" beyond the limits of its actual field of vision. It is not necessary for fish in the center of the school to be

constantly on the alert to potential danger; all they need do is respond rapidly to changes in their neighbors' behavior. The same holds true when a food supply is sighted; then too, the fish in the center are informed. When tuna sight prey, for example, dark bands form on their flanks, signaling other fish that food is nearby. In this manner, many fish can feast even though only a few have discovered the food.

Schooling has other attributes, depending on whether the school consists of prey fish or predators. A theoretical model, based on chance encounters during a given period of time within a large area, indicates that school prey should maintain a highly compact pattern and move very slowly in order to reduce the probability of an encounter with a group of predators. School predators, on the other hand, require encounters. The likelihood of detecting prey is theoretically enhanced if the predators move rapidly in looser schools so as to cover a large area. In fact, both types of schooling have been observed in nature.

When an encounter occurs, it is, of course, disadvantageous to be the prey, but single fish prey are at an even greater disadvantage than school prey. This was demonstrated by a Russian investigator who introduced young coalfish, alone and in schools of twenty-five to thirty-five, to predatory cod. Two and a half minutes elapsed before a cod consumed a single coalfish school member, but only a half minute elapsed before the cod consumed a coalfish introduced singly. The cod was unable to concentrate on any one fish in the school and was distracted again and again from its target fish, switching its pursuit from one individual to another until it finally focused on its victim. The school created a "confusion" effect, which provided time for all the fish to escape from pursuit except, ultimately, the victim.

As mentioned previously, schools generally contain only one species. Experiments confirm that there are advantages to acting and looking like your neighbor. Predators tend to select individuals that differ from their companions; they pursue the weak, the slow, the conspicuous. One experimenter marked prey fish with fluorescent dyes and found that the glowing fish provided brilliant targets for predators. Their shining



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hour came to a quick end. And, in nature, the flash of silver from the gill cover of an anchovy as it feeds pinpoints the fish as prey despite its membership in a school. Because a feeding anchovy no longer resembles its neighbors, it can be picked off.

Even regular spacing of fish in schools works to the advantage of the prey. Edmund Hobson of NOAA watched a grouper intently watching a school of herring. The grouper attacked only three times in two hours-when the school dispersed in response to a diving pelican. Herring that strayed too far from the aggregation were quickly gulped into the grouper's wide mouth. Dispersion also occurs when two prey schools encounter each other and their respective geometric patterns are temporarily disrupted. Before the schools can reassemble, individual fish are particularly vulnerable to predators.

Another survival feature of school geometry applies to prey and predators alike. Studies show that in fishto-fish spacing, both the distances between individuals and their diagonal positions are important factors in the conservation of energy by a school, whether it be prey or predator. A diamond school pattern maximizes the energy available to the member fishes. Fish propel themselves forward by tail thrusts. As the tail sweeps from side to side, it creates vortices, or small whirls of water, in the fish's wake. Depending on its position in the school, one fish can coast on the vortices produced by another in front of it, thus spending less energy on swimming. Fish change position within the school with sufficient frequency to guarantee that no one fish must continuously work harder than any other. In this manner, one fish can utilize the energy expended by another-energy that would otherwise be dissipated and lost-and the over-all effect benefits the entire school.

It is apparent that many good things happen to fish when they take up a schooling life. They have constant companionship and readily available partners during the reproductive season, they make maximum use of available food, conserve their energy, and derive such social benefits as protection from predators and enhanced learning ability.

Evelyn Shaw teaches animal behavior at Stanford University.

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Albinism

by Carl J. Witkop, Jr.

Exiled, revered, or kept as curiosities, albinos have been prominent throughout the ages. Only recently, however, have scientists begun to understand their complex genetic disorder

Albinism, one of the most common and widespread genetic disorders, occurs in plants, insects, fish, reptiles, amphibians, birds, marsupials, and mammals, including all human races. The term albino, from the Latin albus ("white"), was first used in about 1660 by a Portuguese explorer to describe white Negroes he had seen in Africa. But earlier accounts of albinos under such terms as Leukoethiopes (leuko, Greek for "white") are recognizable from antiquity. Pliny and Aulus Gellius described albinos in the first century A.D. It is possible that Noah was an albino. Midrashic accounts state that "his hair was as white as snow, and his eyes like the rays of the sun," the latter possibly a reference to the red reflex from eyes common among albinos. If Noah were indeed an albino, this might underlie the semimythological tradition that Noah's sons, Ham, Shem, and Japheth, were the ancestors of the various races of man. and may reflect man's early attempt to explain racial variation on a genetic basis, rather than the social interpretation that Ham was relegated to the role of servant or slave because he transgressed against his father.

Early explorers of the New World encountered populations with a high

frequency of albinos. They are still found in great numbers among these groups, such as the San Blas Indians of Panama, where one in 143 have albinism; the Jimez, one in 140; and the Zuni, one in 240. Not understanding that the mutation to albinism could arise and become established in a population, early authors speculated that some ancient "white" migration from Scandinavia, Phoenicia, or Egypt must have reached pre-Columbian America to account for these white individuals.

Historically, people with various depigmenting conditions, including albinism, have occupied a spectrum of social positions, ranging from outcasts to semigods. Montezuma, emperor of the Aztecs at the time of Cortes's conquest, maintained a museum of living human biological curiosities; prominent among these people were numerous albinos. People with leprosy, which frequently causes a spotty depigmentation of the skin and hair, are described in biblical literature as the lowest outcasts. Leprosy appears to have been much more common in biblical days than it is today, leading to the supposition that many of the so-called lepers in the Bible in fact had vitiligo, a common, noninfectious, spotty depigmented condition, which can be quite disfiguring, especially in deeply pigmented people. Uzziah, king of Judah, may have left Jerusalem and secluded himself in Ramat Rahel because of nothing more serious than an innocuous, but disfiguring, skin disorder. Not all biblical descriptions of depigmented persons carry this negative connotation. One of the most positive religious statements is the

description of Christ in Revelation 1:14: "His head and his hair were white like wool, as white as snow; and his eyes were like a flame of fire."

Among the San Blas Indians, albinos are called moon children because they avoid the bright sunlight of day and go about their tasks in subdued light. This has given rise to the folklore that albinos can "see in the dark." While albinos can see better in dim light than in bright, they cannot see better in dim light than normally pigmented persons. Among the San Blas, albinos are semioutcasts; they participate less in daytime tribal activities and are not permitted to Biological investigations show that as a group they are somewhat smaller and their muscles are not as well developed as those of pigmented San Blas. These may reflect true genetic differences directly caused by the albino gene; but they could also result from secondary effects of their condition, such as social and nutritional neglect because of their outcast state and poor eyesight.

Under conditions of modern society in the United States, we have been unable to detect any major physical or intellectual differences between albinos and pigmented persons other than those associated with their visual defects and photosensitivity. Albinos

Despite its cream-colored coat and blue eyes—evidence of slight pigment formation—this koala is considered an albino.

Lisl, Photo Researchers









have the same range of I.Q. scores as pigmented persons. Fortunately, their near vision is comparatively better than their far vision, so with judicious assistance most albinos can function well in a public school setting. In our experience, albinos tend to overcompensate in social settings, with many engaging in intellectual pursuits. As a group, our albino patients have a greater proportion of highly educated and professional persons than would be expected.

We now know that there are different types of albinism and that all albinos do not have the same gene defect. All forms of albinism are inherited congenital conditions in which

Since melanin pigment protects the skin against damaging ultraviolet rays, albino animals, such as the emu, left, or the wallaroo, below, are especially susceptible to skin cancer.

there is an absence of or marked decrease in melanin pigment formation. The severe generalized, or oculocutaneous, forms of albinism in animals and humans affect pigmentation of the eyes, skin, and hair. There are also ocular forms, in which only depigmentation of the eyes occurs, and cutaneous, or piebald, forms in which local areas of the skin and hair have no pigment. Depigmentation may also occur in an area that has previously been pigmented, but this condition, generally termed vitiligo, is not a form of albinism.

What is the function of the melanin pigment? Most importantly, it protects the skin cells and the underlying blood vessels and connective tissue from the harmful effects of ultraviolet light. Repeated damage by ultraviolet rays makes the tissues susceptible to "aging" changes (dryness and wrinkling) and to cancer. There is, in fact, a direct relationship between decreasing amounts of skin pigment in different populations and the frequency of skin cancer. Among Negroes, skin cancer is very rare. It occurs much

more frequently in Caucasians, rising in incidence from brunettes to blonds, and is common in albinos. This is not strictly a racial relationship, for A.N. Okoro of Nigeria has observed a high frequency of skin cancer among albino Nigerians.

One of the earliest epidemiological studies of cancer, dating from the eighteenth century, concerned the rate of skin cancer among Dutch fishermen, who were predominantly blonds, and Portuguese fishermen, who were predominantly brunettes. The two groups fished together off the Grand Banks of Newfoundland in the summer months, but the Dutch fishermen had a much higher frequency of skin cancer than the Portuguese, a difference the author correctly attributed to differences in skin pigmentation.

While there is a direct relationship between decreasing amounts of skin pigment, exposure to intense sunlight, and the susceptibility of the skin to aging changes and cancer, this does not mean that blacks cannot get a severe sunburn. But in general, the



Torn McHugh, Photo Researchers



Karl H. Maslowsky, Photo Resea

more deeply pigmented a person is genetically, the less susceptible he is to the damaging effects of sunlight. Thus, we tend to see beautiful "young" skin among older Negroes and "older" skin among Caucasians, especially in the "forty-year-old blond with a beautiful tan," while among albinos, wrinkled "old-age" skin often appears in the early teens.

The normal coloration of all animals, including humans, begins in small specialized cells called melanocytes. Two things must happen-the pigment must be formed properly and it must pass from the melanocytes to the remaining skin and hair cells, the keratinocytes. The melanocytes have long, fingerlike projections (dendrites), which contact the keratinocytes and pass the pigment particles from the melanocytes to the skin and hair cells. There, the particles are arranged over the nucleus of the cell. giving it its coloration. (Incidentally,

the reason your suntan wears off in about three to four weeks is that these outer skin cells are constantly being replaced by new keratinocytes; when the old ones are shed, so too are their pigment particles.)

Melanocytes form pigment in small particles, melanosomes, in a series of steps. Starting with protein and the amino acid tyrosine, the cell first makes an unpigmented particle. the premelanosome, to which the enzyme tyrosinase is attached. This enzyme converts tyrosine to dihydroxyphenylalanine, more commonly called dopa. Dopa, in turn, is converted to a series of intermediate compounds until the final compound, melanin, is formed. If tyrosinase, the crucial trigger, is missing, then the process is blocked at the first step, and pigment cannot be formed.

In 1908 a perceptive scientist, A.E. Garrod, proposed that the cause of albinism was a change in the genes The incidence of albinism varies among species; exceedingly rare in rattlesnakes, it is not uncommon in squirrels and catfish. Since catfish are bottom feeders, relying little on eyesight, albino individuals survive fairly well in the wild

that direct the formation of the enzyme tyrosinase and that albinos lacked this enzyme function. Hence, albinism was an example of an inborn error of metabolism. Until recently, it was believed that all albinos lacked tyrosinase.

Geneticists early in this century noted that most albinos were the offspring of normally pigmented parents, and that only about onefourth of the offspring of these







parents were albino. Thus, albinism seemed to fit Gregor Mendel's model of inheritance of an autosomal recessive trait. Pigmented parents of most albinos carried a recessive, or hidden, gene for albinism. These parents would have one normal gene for pigment formation, which was sufficient in the single dose to determine normal pigment formation. Thus, the trait "normal pigment" was dominant to the recessive trait "albinism." According to the model, if two albinos mated, all offspring would be albino.

It soon became apparent that this relatively simple explanation did not account for all families in which albinism was found. Early investigators noted that some albinos had snow-white hair, even those with Negroid ancestry, while others had a yellow tinge to the hair and some pigment formation in their eyes.

Working at the National Institutes of Health, T.P. Kugelman, E.J. Van Scott, and I were the first to define the existence of at least two forms of albinism, having biochemical and clinical differences, in humans. A simple test could differentiate albinos who lacked the enzyme tyrosinase, as proposed by Garrod, from those individuals who had the enzyme but were albino because their gene mutation affected pigment formation at a step other than that involving tyrosinase. Both types have melanocytes in their skin, hair, and eyes, but these cells do not form pigment properly.

We placed hair bulbs from albinos in a solution containing the building block of pigment, the amino acid tyrosine. If all albinos lacked the enzyme to convert tyrosine to dopa—the first step in pigment formation—then albino hair bulbs would not form pigment in this solution. We found, however, that the hair bulbs from most albinos did, in fact, form black pigment, indicating that they had the enzyme tyrosinase. But we never

Extreme sensitivity to light causes an albino child to squint in the sun of his Liberian village. In some cultures albinos are called moon children because they go about at night.

Richard Dranitzke, Photo Researchers

found an albino who pigmented and one who did not pigment in the same family—all pigmented or all did not pigment—leading us to suspect that there were two biochemical forms of albinism that were controlled by different genes.

Final genetic proof of this system came when we found two families in which both parents were oculocutaneous albinos but whose children were all normally pigmented. On testing the parents, we found that one parent in each family was able to form pigment with the hair bulb test, while the other could not. Thus, the parents were different kinds of albinos, both genetically and biochemically. Each had two defective genes blocking pigment formation but at different points in the pigment system. Each parent gave the children the factor that was lacking in the other parent; that is, they complemented each other's defect, so that each child received one normal gene at each point at which the parents were defective.

Since that time, biochemical investigations of albinos have shown that there are at least six different genetic blocks (biochemical errors) that result in disorders with features of oculocutaneous albinism in humans.

Tyrosinase-positive albinism, in which the albino has the enzyme tyrosinase and can form slight amounts of pigment, is the most frequent form in humans. It occurs in about one in 36,000 Caucasians and one in 15,-000 American Negroes; all Amerindians, Japanese, and Chinese tested to date have been of this type. Since pigment formation is delayed in infancy, it is difficult to tell this type in all races without detailed biochemical studies. In general, these individuals formsome pigment. They have yellow hair, slight pigmentation of eyes, and experience less severe eye problems than the complete albino, the tyrosinase-negative type.

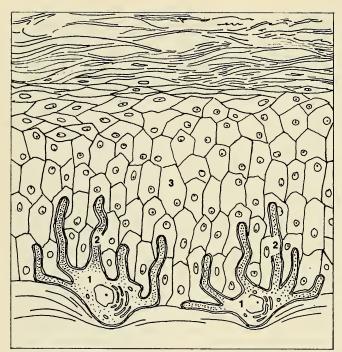
Tyrosinase-negative albinism, the most frequent form in animals, appears to be a defect in the enzyme tyrosinase. Human albinos of this type have complete absence of pigment, snow-white hair, and severe visual defects. The second most frequent form, it affects about one in 40,000 Caucasians and one in 28,000 American Negroes.

There are also other, rarer types of

albinism. These include the yellow mutant form, Chediak-Higashi disease, Hermansky-Pudlak syndrome, and Cross syndrome. The yellow mutant form produces red or yellow pigments and is found in Negroes and Caucasians, especially among the Amish. Chediak-Higashi disease affects the membranes of intracellular particles so that giant particles are formed in all cells that produce cytoplasmic particles, including white blood cells as well as pigment cells. It has been found in humans, mink, cattle, bison, whales, and mice. Individuals with the Hermansky-Pudlak syndrome-found among Czechs, Poles, Germans, Irish, English, Dutch, Puerto Ricans, Japanese, and East Indians—have tyrosinase-positive albinism, a mild bleeding defect due to a blood platelet defect, and an accumulation of an abnormal waxlike fat in tissues. These albinos are exquisitely sensitive to aspirin and aspirinlike drugs, which may make their bleeding problems worse. Since many patients with this disorder have died of bleeding following aspirin ingestion, all albinos should be tested by an advanced hematology laboratory to find out if they have the Hermansky-Pudlak defect. Cross syndrome consists of albinism, enlarged gingivae, mental retardation, small eyes, and spastic movements.

Most of what we know about the genetics of pigment formation has been learned from studying mice. There are more than seventy genes at forty different loci that affect skin, hair, or eye color in mice, suggesting that pigment control in humans may be equally complex. A large number of genes at different loci can, in single or double dose, produce white or very light-colored animals. Some dominant white mutations produce animals with white coats but dark eyes. A double dose (homozygosity) of the pink-eye gene gives pink eyes similar to the eyes of albinos and a light-colored coat but not the completely white coat of the albino. The microphthalmia gene produces animals that look very much like albinos, in fact, they are often called mock-albinos, but in addition to having very small or nearly absent eyes they lack melanocytes in skin, hair, and eyes.

Not all white animals are true albinos. True albino animals are consid-



How Skin Pigment Is Formed

The coloration of skin begins in special cells called melanocytes (1). Through a complex biochemical process, the amino acid tyrosine is converted to particles of melanin pigment by the action of the enzyme tyrosinase. This enzyme is the crucial trigger in the process; if it is missing, as it is in many albinos, the process is blocked at the first step and pigment cannot be formed. (In other albinos the process is blocked at different stages, and slight amounts of pigment can be formed.) Fingerlike projections of the melanocyte (2) enable the pigment particles to pass to the skin cells, or keratinocytes (3). There, they are spread over the nuclei, giving the cells their coloration. Since the skin cells are constantly being shed and replaced by new ones, their pigment particles are also sloughed off, which is why a suntan fades in three to four weeks.

ered to be those that have melanocytes in their skin, hair, and eyes, but these melanocytes lack tyrosinase. Other mutations occurring at the same point on the chromosome where the gene for tyrosinase formation is located affect tyrosinase to a lesser extent, allowing some pigment to form. Among these mutations are the Himalayan and Chinchilla genes. The Himalayan gene, found in rabbits, rats, and mice, produces white animals with black paws and black tail and ear tips, the pigment forming in those parts of the body with lower temperature. The names for these genes vary somewhat with species, so that the Siamese gene in cats is probably equivalent to the Himalayan gene. The Burmese gene in cats and the Chinchilla gene in many animals also affect tyrosinase, producing animals with a light coat color. White tigers, whose mutation is similar to Burmese cats, have a white coat in the normally yellow area, but still have black stripes. They also have some eye pigmentation.

White phases of pigmented ani-

mals are not true albino types. These color phases are found primarily in arctic-dwelling animals-polar bears, arctic foxes, and arctic hares. In summer, these animals have a darker coat, but with the advent of winter the pelt turns white. This color-change phase is probably regulated by the seasonal variation of light falling on the eye, which stimulates the release of hormones that regulate pigment formation. One characteristic that distinguishes these color phases from true albinism is the presence of darkly pigmented eyes. In essence, the arctic-phase adaptation is the opposite of the Himalayan gene. No doubt, this color-phase change has adaptive survival value for animals-both predator and preyagainst snow- and ice-covered arctic backgrounds.

Dominant white mutations also differ from true albinism in that matings between white animals produce both white and normally pigmented animals. Many so-called albino horses, cattle, and deer are not true albinos but are animals with dominations also deep the second s

nant white mutations. An excellent example of the emergence of a dominant white strain of animals is the herd of white deer that has become established at the Seneca army depot in upper New York State. The New York State Department of Environmental Conservation declared the depot a game preserve. Two white deer were first noticed in 1957 among an estimated population of 2,000 to 2,500 normally colored deer. By 1960 seven white animals were counted in the herd. There was a rapid increase between 1960 and 1970, when 225 to 250 white animals were counted, amounting to about 10 percent of the herd. It thus appears that in the environment of semiprotection provided by the refuge, whiteness per se is not a particularly disadvantageous trait and may even, under appropriate conditions such as a winter background, provide some survival advantages. That the dominant white deer increased in greater proportion than the normally colored deer, however, does not by itself indicate a survival advantage for the white animal—normally colored animals may have been removed while the white animals were left alone.

Many color variations in animals are associated with alterations in other systems that may underlie the selective advantage or disadvantage of the color mutant over the normally colored animal. The Aleutian, or blue, mink, for example, has a defect in white blood cells, making the animal susceptible to infections. It is this defect that has the greatest selective disadvantage for the animal, not the coat color change, which may make the animal more susceptible to predators.

The idea that certain color changes in organisms renders them more susceptible to predators is nonetheless valid. An interesting study in England attributed the predominance of darkly melanized moths found today, as opposed to the predominance of light-colored moths in preindustrial Britain, to the blackening of vegetation by industrial pollution. Because melanized moths can better escape detection, they have become the predominant form of the species. (Interestingly, the moths are becoming lighter in color in those areas where pollution is being reduced.)

It would seem that albino animals would have a disadvantage against dark backgrounds, but an advantage against lighter backgrounds, particularly in snow. Unfortunately, there have been few studies on the survival of albino animals in the wild state.

Albinism probably occurs more frequently in certain species of animals than in others. Albino squirrels are quite common, while albino robins are less often observed. Albino catfish are frequently caught by commercial fishermen. One study testing the survival of albinos in the wild was done by R.W. Menzel, who released a large number of albino catfish in a river system of Virginia. Since catfish are bottom feeders, depending little on eyesight, the visual defect of the albino fish was probably not a great disadvantage. The recovery of the albino fish by commercial fishermen indicated that these fish survived fairly well in the natural state. But not all species of albino catfish survive as well. The walking catfish, which now constitute an ecological problem in Florida, were originally released

from private aquariums and were predominantly albinos. Today, in the wild state, few albinos are encountered; most of the fish are the pigmented variety. Many of these pigmented fish are undoubtedly heterozygous and hence pigmented, but one suspects that the selection against the albino fish greatly reduced their numbers if, as reported, the original fish were predominantly albinos.

Whether albino animals have a disadvantage in mate selection is a question for which little evidence exists. A rare albino rhesus monkey, a resident in the New Orleans Zoo for many years, has mated with only one female. Further, the animal is now separated from the monkey colony because of the abuse he received from the pigmented animals.

If the evidence in albino mice is a valid generalization, albino animals may have a reduced reproductive fertility. In our mouse colonies, albino mice have less frequent litters and fewer offspring per litter than do our pigmented animals. How do we know that this is due to the albino gene? In animal strains where the black animals differ genetically from the white by only one gene, the albino gene, this reproductive differential is also apparent. While it may be tempting to conclude that this difference is related directly to an immediate effect of color, recent evidence suggests that there may be another, more indirect cause. Dominant white animals do not show the reduced reproductive fitness of the albino.

Albino wild animals, like albino humans, are susceptible to skin cancer. Albino and white horses, for example, frequently develop malignant melanomas, as do albino fruit flies. It is the albino animal's visual defect, however, that is probably the most detrimental to its survival.

In animals with laterally placed eyes and panoramic vision, such as most fish, amphibians, and birds, nerve tracts from the eyes (optic tracts) completely cross the midline and go to the opposite side of the brain from the eye of origin. The point at which the nerves cross is called the optic chiasm. As one proceeds along the phylogenetic orders of animals, eyes assume a more frontal position in the face and there is an increase in the amount of binocular vi-

sion. As the field of binocular vision increases, there is an increased proportion of fibers that do not cross at the midline but go to the same side of the brain as the eye of origin; thus, in rats about 5 to 10 percent of fibers do not cross the midline, in dogs and horses 15 to 20 percent, in cats about 30 percent, and in primates, including humans, about 45 to 50 percent. This arrangement is necessary to permit depth perception.

Recent studies have shown that albino rats, rabbits, guinea pigs, ferrets, mice, and mink have abnormal nerve tracts from eye to brain. Most of the fibers that should stay on the same side as the eye of origin do not; rather, they cross to the other side, similar to the pattern in more primitive animals with panoramic vision. Human albinos also have the same type of defect. In general, they lack the ability for binocular vision and depth perception. Since this type of optic tract defect is associated with mutations that result in lack of pigment in the developing optic cup, the defect is not limited to true albinos.

Most laboratory animals are albino or hypopigmented types, selected for their docility and, perhaps, their greater esthetic appeal. Knowing now that these animals are not neurologically normal, we should reevaluate the results of many studies, particularly in the fields of psychology of learning, eye physiology, and neural development.

It is also known from recent studies that albino animals differ in their susceptibility to alcohol. Following a standard dose of alcohol, black mice sleep an average of 65 minutes; black heterozygotes, an average of 81 minutes; and albinos, 175 minutes. Knowing, too, that one form of albinism is associated with platelet and lipid defects, which affect normal responses to drugs such as aspirin, we should also reconsider the results of past drug tests.

As we learn more about albinism and the constellation of disorders with which it is associated, exciting avenues are opening in our research on the role of pigment—and mutations controlling pigment—in neural development and embryology, brain function, drug metabolism, visual physiology, and many other areas of molecular biology.

A Forestry Scheme in Samoa

by Paul Shankman

When a large American corporation invests in a tropical island nation's natural resources, many problems arise . . . with few easy solutions

The mild tropical climate and physical beauty of Western Samoa are what first attracted Robert Louis Stevenson to this small group of Polynesian islands in 1890. Stevenson, fleeing from what he called the "meteorological purgatory" of his native Scotland, found the islands an ideal setting for the last years of his life. If the noted author were to arrive today, he would still find the quiet coastal villages with their blue lagoons and the lush tropical rain forests of the unpopulated interior. But he would also witness some remarkable changes in the Western Samoan landscape: one lagoon is being filled to provide a foundation for a luxury hotel, and the rain forests are being harvested for their marketable hardwoods. These commercial developments were, to a certain extent, anticipated even in Stevenson's time. One visitor to the author's Samoan estate could not imagine that the rain forests would remain in pristine condition for any length of time. She commented that "though in the midst of grand forest trees, the Samoans have not as yet begun to utilize what might be to them a source of wealth. and it will in all probability be left to some enterprising white man to start sawmills and find out the real value and utility of the superabundance so lavishly provided by Nature."

This observation, made in the 1890s, reflects some common misconceptions about the nature and value of Western Samoa's rain forests and the relative abilities of Samoans and whites to realize that value. These same misconceptions lie at the heart of current economic development efforts involving the large-scale harvesting of Samoan timber by foreign investors.

The commercial milling of hardwoods began in the late 1960s as part of Western Samoa's plan to promote economic development through foreign investment. Today's timberharvesting schemes—primarily American and Japanese—are the result of a development doctrine aimed at encouraging Western Samoa to use its resources to form closer economic ties with the wider world. While this idea dovetails nicely with foreign investors' plans for the islands, until recently private foreign capital aroused considerable apprehension among Samoans. In 1947, a foreign furniture company attempted to establish timber-milling operations in Western Samoa, but opposition by Samoans, expressing their fears about the precedent for large-scale foreign investment, was so intense that the proposal was withdrawn. Although present investment in the islands' timber no longer creates such apprehension, its role is nevertheless uncertain. To understand why this should be so, a look at Samoan life and the effects of commercial milling

on the Samoan economy is necessary.

Western Samoa today is an underdeveloped country whose physical attractiveness has been mistakenly equated with the idyllic abundance of a tropical paradise. Perhaps because of their romantic imagery, the islands' very real problems tend to be overlooked. Further confusion is added because Western Samoa is often lumped with its neighbor, the United States territory of American Samoa, whose problems are somewhat different. More than anything else, Western Samoa is an independent country trying to cope with a rapidly expanding population, diminishing amounts of land relative to population, and a deteriorating agricultural economy.

The majority of Samoans are peasant cultivators who have one of the highest natural population-growth rates in the world. Although the present population numbers only 155,000, it has almost quadrupled in the past fifty years. Of this total, about 11 percent are Europeans and part-Samoans who live in the islands' only town, Apia, while most of the 'real' Samoans, as they call themselves, live in the small rural villages

Most of the rugged surfaces of Western Samoa's two principal islands, Savaii and Upolu, are covered with dense rain forests.





that dot the coastlines of the islands.

The peasant cultivators live in extended family units, each with access to fragmented plots of land for agriculture. Using a variation of the slash-and-burn technique, the Samoans plant some of their land in taro, bananas, and coconuts for their own consumption, together with such crops as coconuts (later processed into copra), cocoa, and bananas for export. The remaining land is allowed to lie fallow. The increase in crops raised for subsistence and export, coupled with an expanding population, means that most of Western Samoa's agricultural land has already been cleared. Within fifteen years, all such land will be in use, putting considerable pressure on an agricultural system that relies on fallow periods for soil regeneration. And it will also put pressure on the rain forests from which Samoans have traditionally carved out new agricultural land, as well as taken materials to be used for housing, canoes, and firewood.

In addition to looming land shortages and depleted forests, Western Samoa's economy is faced with decreasing agricultural productivity. Between 1900 and 1970, per capita copra production actually declined. Furthermore, large fluctuations in the world market prices paid for copra, cocoa, and bananas have meant that the average income from agricultural exports has hardly risen since World War II. The result is that a Samoan peasant presently earns, on the average, less than \$100 a year, a figure that in 1971 led the United Nations to classify Western Samoa among the seventeen poorest countries in the world.

This status, however, is hardly warranted; it rarely is in countries that are underdeveloped but living in conditions of tropical affluence. Such countries do not suffer from the kind of poverty found in areas where there are chronic land shortages, desperate food shortages, high infant-mortality rates, and short life expectancies. In





each of these respects, Western Samoa is still relatively well-off, and the slow economic decline of the past half century has not been regarded with particular alarm. Nevertheless, it has been clear for some time that the present agricultural system cannot continue to support the islands beyond the near future.

As a United Nations Trust Territory under New Zealand mandate until 1962, Western Samoa did not have direct responsibility for its gradually worsening economic situation, but as independence approached in 1962 the problems became increasingly apparent and a variety of development alternatives were considered.

At this time, the U.N. Development Program in Western Samoa guided the islands' development focus. In its 1963 report, the United Nations emphasized that the most important task for the newly independent country was to get agriculture moving. Secondary development targets included fishing, light industry, and forestry, but the major thrust of this and earlier reports was the rehabilitation of peasant agriculture. Private foreign investment was recommended as a means by which these development objectives could be realized; foreign investors, however, were reluctant to become involved in agricultural improvements. Prospects for profit in

The Potlatch Corporation lumbers a dozen of Western Samoa's hardwood species. The government now replants much of the cleared area with mahogany seedlings.



the harvesting of the great Samoan rain forests were more attractive.

One foreign firm interested in timber harvesting was the Potlatch Corporation, one of America's larger wood and wood-products companies. In its stockholder publication, Potlatch cites the 1963 U.N. study as the beginning of its efforts to "launch Western Samoa into the mainstream of economic development." Contacts between Potlatch and Western Samoa were, in fact, initiated by the regional director of the U.N. Development Program in Western Samoa, who had originally commissioned the U.N. study recommending secondary forestry development. Shortly thereafter, in 1965, Potlatch began surveying the tropical hardwoods on the island of Savaii, Western Samoa's last great stand of timber. Here Potlatch found over a dozen species that could be used for furniture and veneers. The names of these hardwoods are exotic-tava, mamalava, tamanu, asi, malili, gasu-but the timber is eminently suitable for American, Japanese, and other Pacific basin markets.

Following the timber survey on Savaii, Potlatch began contract negotiations with the government of Western Samoa. Although Potlatch claims that it was "selected by the Western Samoans," most islanders had little idea of what was being planned on their behalf. The negotiations themselves took almost a year, with close relationships between the United Nations and Potlatch helping to smooth the way for the largest single business venture in Western Samoa's history. While the Samoan peasants had little direct voice in the negotiations, the Potlatch lobbyists met both formally and informally with members of the Samoan Parliament. Among the lob-

Potlatch's influence in Western Samoa began in 1968 with the construction of a sawmill and port facilities on Savaii. All timber cut on the island is now processed at the mill, then shipped to foreign markets. principally in America and Japan.

byists was the same regional director of the U.N. Development Program who had introduced Potlatch to Western Samoa. Potlatch had hired him as an adviser shortly after his retirement from the United Nations, and he presented Potlatch's formal proposal to the assembled members of Parliament.

Basically, Potlatch wanted to invest about \$6 million (by 1975) in a milling operation and a continuous-resource tree-farming project that would involve the leasing, by early estimates, of between 14 percent and 23 percent of the entire land area of Western Samoa. The scope of the Potlatch proposal would necessarily have broad implications for Samoan land policy, the ecology of the rain forests of Savaii, and the Samoan government's future commitment to Potlatch and other multinational investors.

The leasing of such an enormous land area was a major precondition for the Potlatch program. Well before Potlatch arrived, however, it was evident that even small-scale private investment was on a collision course with Samoan communal land law, which explicitly prohibited the sale or lease of Samoan land to anyone, including other Samoans. Without being able to lease or purchase land, foreign investments would not be secure. To encourage foreign capital, in 1962 the law was modified to allow the leasing of land for commercial, industrial, and tourist purposes. But for a large-scale leasing arrangement such as Potlatch sought, it was clearly necessary to make special provisions that would circumvent the land-tenure system.

The roots of this unusual system lie in the colonial past. Ever since large parcels of land were alienated to European plantation owners in the midnineteenth century, Samoans have been acutely aware of the need to control their land. In 1921, while still under New Zealand mandate, Western Samoa's quasi-traditional system of land tenure was codified into law and now applies to 80 percent of the islands' land. Under this system, extended family units in each village hold title over various plots of land that are owned through use. When not in active use or fallow, the land may revert to the village as a whole or to other families who will use it. To complicate matters, land is jointly owned by the whole extended family, including kin in other villages who have a potential voice in land use even though they do not reside on it. Actual decisions about use lie with an elected family head, or titleholder, who, in consultation with his own family and with other titleholders in the village council, manages land-use policy. If conflicts within families, between families, or between villages cannot be resolved, they are referred to the national Land and Titles Court, an institution set up to handle just such litigation.

As long as land was abundant and was not a commodity, this system of communal land tenure was viable, and conflicts could be kept at a minimum. Although relatively inefficient in strict economic terms, the system supported the Samoans quite adequately, and in the process, the mastery of its labyrinthian complexities helped the Samoans to become astute politicians. As land became scarce, however, and as more profitable landuse alternatives were foreseen, the traditional system came to be regarded as a barrier to economic development.

Although limited leasing had been approved in 1962, massive leasing by Potlatch would be a formidable task given the normal conditions under which leasing would take place. If Potlatch wished to lease the land, it would have to negotiate hundreds of leases on a family-by-family and village-by-village basis. Arrangements would have to be made in a foreign language, and contracts would have to be designed to cope with a system in which management and ownership functions were separate. Furthermore, since much of the land was unsurveyed, conflicts over ownership could involve litigation that would prevent the Potlatch project from ever getting off the ground. To bypass these difficulties, Potlatch requested that the Western Samoan government set up an agency to act as a land broker on the corporation's behalf.

This request was one of several concessions that, when approved by the Samoan Parliament, would facilitate the Potlatch project. Among the others were renewable twenty-year leases, a replanting program carried

out by the government to replace timber harvested by Potlatch, a tax moratorium, customs exemptions, repatriation of capital privileges, foreign exchange privileges, personnel privileges for Potlatch employees, and property leases from the government for the millsite in addition to the harbor concession to be built by the government. For its part, Potlatch planned to invest several million dollars that, according to the company, would provide jobs for Samoans, supply revenues to the government, and substitute domestic lumber production for foreign imports. Potlatch also would construct roads, power plants, and logging facilities on part of the island of Savaii, and develop a program for systematic forest use.

The terms of the Potlatch proposal were not automatically accepted at either the national or the village level. At the national level, members of the Samoan Parliament debated the issue through 1966 and 1967. Potlatch lobbyists consulted informally with members of Parliament, and the Prime Minister of Western Samoa, Fiame Mata'afa Mulinu'u II, visited Potlatch operations in the United States. On his return, the Prime Minister became the most important advocate of the Potlatch proposal, reassuring members of Parliament that leasing would bring economic prosperity to poor Samoans. Noting that there were two economic classes in the islands—the rich but landless Europeans and the poor but landed Samoans-the Prime Minister maintained that the Samoans could help themselves by leasing their land.

At the village level, the advantages and drawbacks of leasing were also debated. In the small villages of western Savaii, the island on which Potlatch would set up its operations, the obvious monetary advantage seemed attractive. This area, with about 14 percent of Western Samoa's population, is one of low agricultural potential and low income, so the interest in leasing was understandable. Nevertheless, the villagers considered the possibility that the twenty-year renewable leases would put pressure on remaining agricultural land that could be brought into subsistence or cash crop production. Although most of the land leased by Potlatch is not suitable for agriculture, villagers feared that in areas where there was potential for both forestry and agriculture, leasing would mean relinquishing their rights to farm the land. In one instance, Potlatch uprooted coconut trees on leased land to make way for a road. The villagers asked to be compensated for their loss at \$42 a tree; they received only \$7 a tree.

Once the Samoan Parliament approved the Potlatch proposal in 1967, the possibility of leasing sparked a new interest over the use, ownership, and boundaries of land in the villages of western Savaii. Disputes arose as land between villages suddenly became a commodity. Anthropologist Sharon Tiffany describes one case in which two villages claimed title to land long ignored by both. The dispute could not be resolved locally and the national Land and Titles Court finally ruled that neither village owned it. Other means of obtaining land were employed during a minor wave of land speculation; for example, one wealthy titleholder tried to extend his holdings by clearing additional land so that he would have more acreage to lease to Potlatch for tree farming.

The monetary rewards, which the Samoans anticipated from leasing, did not prove as great as expected. The first property to go was the 181acre sawmill site owned by the government and leased at a fixed rate of \$1,500 a year for a twenty-year period (about \$8 per acre), a low sum considering the increasing value of the land over that period of time. The first leases from Samoan peasants were substantially lower: \$1.40 an acre. In 1969, Potlatch leased 28,000 acres from a group of seven villages with a total population of about 2,600 people, bringing the average yearly per capita income from leasing to a little under \$11. Villages receiving leasing advances in a lump sum can receive much higher amounts. One small village received almost \$20,-000 in a single payment. But this kind of arrangement masks the annual amounts to be made from leasing, which are not very large even in terms of the low over-all income of the peasants. Royalties paid on cut timber may help, but they are also low-about four cents per cubic foot, part of which reverts to the government for reforestation.

The economic effects of the Potlatch operation extend well beyond leasing and royalty fees to villagers; revenues to the government and jobs for Samoans are supposed to help balance the development ledger. Early studies suggested that a nominal investment of \$260,000 by the government of Western Samoa in industrial infrastructure, especially wharf and harbor facilities, would yield about \$13 million in revenues from Potlatch over a twenty-year period. Unfortunately, the government's infrastructural estimate turned out to be too low. Building harbor and wharf facilities for Potlatch's use ended up costing the government almost five times the projected initial figure. By "some incredible engineering miscalculation" (as one reporter put it), foreign engineers failed to carefully examine the harbor bottom that was to be dredged for a shipping channel: it turned out to be solid coral. Instead of the simple dredging that had been scheduled, a lengthy blasting and dredging job was necessary. In 1972, dredging was still under way, even though the wharf had been completed in 1968, and the delays caused friction between Potlatch and the Samoan government. From an economic perspective, the repayment of principal and interest on the loans used to cover these infrastructural developments will cut deeply into the revenues anticipated from Potlatch. By 1970, the government had already concluded that Potlatch's contribution to the country's balance of payments problems would be small.

Although direct revenues to the government and help with balance of payments problem did not meet original expectations, by 1975 Potlatch was providing employment for 300 people, making the corporation one of the islands' major employers. Yet, in the context of an underdeveloped economy like Western Samoa's, it is important to understand that these new Potlatch employees were not necessarily unemployed when they were hired by the corporation. What Potlatch did was shift employment opportunities, through training programs, from agriculture, civil service, and light industry to forestry; this can be viewed as an upgrading of the labor force. At the same time, though, by leasing enormous tracts of



land, Potlatch will, at a certain point, create a situation in which Samoan peasants may not have sufficient land on which to carry out peasant agriculture. Samoans will then begin to lose employment in peasant agriculture, and given the scarcity of land, coupled with population growth, Potlatch may be contributing to unemployment in peasant agriculture while creating employment in forestry.

An additional problem has to do with the rising cost of living as people move from a subsistence-oriented peasant economy to a consumeroriented wage labor economy. While Potlatch pays much higher wages than peasant agriculture, Potlatch employees may no longer have the time or the land to cultivate subsistence crops; they must therefore import food and other necessities, paying for them with cash. On a longterm basis this means that the real cost of living is likely to rise and that high wages by Samoan standards may not be able to offset these rising costs. In already commercialized areas of Western Samoa, this trend-rising incomes, coupled with even more rapidly rising costs-has led people to migrate overseas in order to improve their unstable position in a consumer economy.

Apart from its social and economic effects, the Potlatch proposal may have considerable effects on the ecology of the tropical rain forests in Western Samoa. Although the rain forests were thought to be an inexhaustible resource in Robert Louis Stevenson's day, this is no longer the case. Throughout the world, primary tropical rain forests are threatened by human use to such an extent that they are in danger of vanishing by the end of this century. Well before Potlatch arrived, the rain forests of Western Samoa were threatened by such normal processes as population growth, agricultural expansion, and the domestic use of timber. A study con-

Future generations of Western Samoans will be severely affected as a rapidly expanding population requires more and more land.

ducted almost two decades ago warned that unless rapid and coordinated remedial measures were taken, the forests, which seemed so abundant, could disappear within two generations. The presence of a largescale commercial milling operation may hasten this trend, irreversibly damaging the primary rain forest through the alteration of forest composition and erosion patterns. Geographer Peter Pirie of the University of Hawaii has recently observed that the area leased by Potlatch contains the only remaining stand of large tropical hardwoods in the country and that it could be quickly exhausted.

Potlatch has maintained that their strategy of continuous-resource treefarming would replace the primary rain forest with rapid-growing timber varieties that would not only regenerate the forests but also be financially remunerative. The reforestation program, however, is not Potlatch's responsibility; as part of the Potlatch contract, the government of Western Samoa has agreed to replant as Potlatch cuts. But in 1973, as Potlatch was getting into its harvesting program, much of the basic research on replanting had not yet been carried out. Some government officials were concerned that further delays could lead to erosion problems and also create undesirable types of secondary growth.

When all the economic, social, and ecological changes which could affect the people of Western Samoa due to Potlatch's presence are considered. it is apparent that the Western Samoans are taking a larger gamble than is the corporation. Potlatch can measure its successes and losses by calculating the financial return on its investment; no such clear-cut standard can be applied to these people or their islands. It is the inevitability of the corporate balance sheet, however, which will ultimately determine the fate of the Samoans. If Potlatch realizes high profits, it could recoup its investment within five years, and if tree replanting is carried out, it could remain indefinitely in Western Samoa. But should Potlatch's Samoan subsidiary fail to yield sufficient annual returns, the corporation might pull out. Under these circumstances, it becomes inevitable that the firm's interest in economic development must be compatible with corporate profit.

The Western Samoan government is aware that corporations are interested in investing in those sectors of the economy that are most profitable, rather than those most in need of development. While investments in forestry and tourism have been high, the peasant agricultural sector continues to deteriorate. In this light, the high praise for Potlatch by some development officials will be of little consolation to the Samoan peasant. Although Potlatch can hardly be expected to invest in agriculture, its timber-harvesting program has diverted both governmental attention and funds from the basic problem of agricultural development. Furthermore, to have any effect on the majority of Samoans, the limited revenues from Potlatch will have to be reinvested in peasant agriculture.

For the Samoans within the Potlatch orbit, there is little concern about the abstract goal of economic development. Their feelings revolve around concrete problems-and these feelings are mixed. There is a general acceptance of Potlatch, especially by the small group that is doing well because of the corporation's presence. But other Samoans have questions concerning the amount of land leased and the prices that Potlatch has paid for both land and timber. Samoans wonder about the pollution at the millsite; there is also some resentment against Samoans from other parts of Western Samoa who are now employed by Potlatch in western Savaii. Generally, Samoans suspect that Potlatch is taking advantage of them as other Europeans have in the past. The depth of these feelings is rarely understood or appreciated by most Europeans.

Many Samoans realize that Potlatch and other foreign investors cannot be relied upon to provide them with the jobs, incomes, and futures that they desire. But their alternatives are limited, and corporate promises of progress are tempting. Potlatch has advertised that, from Samoa to San Francisco, its products will "help make a better life possible for everyone everywhere," but this vision of a corporate paradise on earth is no more convincing than the romantic imagery that once surrounded Western Samoa. If the reality of economic development turns out to be as unsatisfying as the mythology of tropical paradise, poor Samoans may remember Robert Louis Stevenson's advice on the use of the islands' resources: "It is to make roads, and gardens, and care for trees, and sell their produce wisely. . . . If you do not, others will."

A commentary by Roderick M. Steele Executive Vice President, Operations Potlatch Corporation

We appreciate the opportunity to comment on the article regarding Western Samoa.

The description of Potlatch Corporation as one of the United States' larger wood and wood-products firms is probably misleading. Potlatch's annual sales makes us about the fifteenth or sixteenth largest forest products firm in the United States.

Likewise, the description of Potlatch's initial involvement in Western Samoa is misleading. Potlatch officials did indeed contact and discuss with Western Samoan government officials the feasibility of both parties achieving their objectives through an investment by Potlatch in Western Samoa. But prior to our involvement, other parties had made approaches to Western Samoa regarding the harvesting of their forestland. The government of Western Samoa had the choice of which forest products firm, it would do business with, and the fact that they were aware of Potlatch before other firms seems irrelevant.

In describing the twenty-year forestland leases, which include clauses for replanting as well as harvesting, the author concludes that village land would be used primarily for corporate purposes. We disagree. The forestland is an economic asset of the country. The harvesting of mature and overmature trees is the means by which their economic value can be realized by Western Samoa.

We also take issue with the author's comments on the problems posed by our arrangements for leasing forestland. Whether this land is best suited for growing food or trees is, under the terms of our contract, entirely up to the Western Samoans to decide. Some formerly forested land is now being used for agricultural research, and villagers are now growing crops on other land which has recently been cleared. In addition, forestry plots have also been established to determine the types of trees that will best produce future forests. Potlatch voluntarily assisted in this latter program by starting a nursery and providing seedlings to the government at no cost.

One tangible realization of economic value by Western Samoans is the royalty, or fee, paid by Potlatch for the timber harvested, an amount which is implied to be inadequate. Again, we disagree. The economic value of forestland in Western Samoa or anywhere else reflects the utility and value of the end products of such land. To date, the results of our efforts to market the Samoan hardwood indicate that the royalty is too high.

In contrast to the economic benefits realized by Western Samoa, Potlatch-Samoa has so far lost over one million dollars on this venture. The

parent Potlatch Corporation has also incurred losses on the products it has purchased from its operating subsidiary and resold in the United States. The parent company, however, has made no charge to its operating subsidiary for the cost of capital invested in Western Samoa, which now exceeds \$6 million, and no charge for the administrative services provided by parent company personnel.

Whether Potlatch has provided the type of investment that will be beneficial to the solution of the economic problems of Western Samoa is inadequately discussed. The article fails to recognize the basic issue of how wealth is created. We suspect that the other industries in Western Samoa cited by the author include many that provide little new capital investment but which are simply service-type businesses. A large number of hotel rooms have been constructed in and around Apia in the past several years. While these attract tourist money, they also raise serious problems as to the impact of this type of activity on Western Samoan society.

From the standpoint of Potlatch,

our investment in Western Samoa has not been successful. This is true for a number of reasons, not the least of which are mistakes on our part. However, we believe that from the beginning we have acted in an ethical, straightforward manner. There are no secret deals—all agreements are encompassed in legal instruments or legislation that has had the support of duly elected officials.

We think our investment in Western Samoa has been beneficial to the economy of that country and, consequently, to the people. Additional time is needed to make a more complete assessment. But, the important point to remember is that the Western Samoan people have the ability and means to make that judgment.

Since 1971, about 300 Western Samoans have worked for Potlatch, making the corporation one of the islands' largest employers.



Celestial Events

by Thomas D. Nicholson

Sun and Moon The sun is in the constellation Virgo throughout October. At the end of the month, it moves into Libra, where it remains until the 23rd. Moving rapidly south as it passes through these constellations, it crosses the sky in a path that lowers and shortens day by day. The duration of daylight diminishes from 11 hours 16 minutes in mid-October to 10 hours by mid-November.

The moon is in the evening sky in mid-October, remaining later each night until it becomes full on the 20th. As it wanes, it rises later after sunset each night, becoming last-quarter on the 27th and new on November 3. Reappearing as an evening crescent about November 6, it will again reach first-quarter phase on November 10 and full on November 18.

Twice in November, sun, moon, and earth will be close enough in line to produce eclipses. A partial solar eclipse on November 3 will be visible in the far Southern Hemisphere. A total lunar eclipse on November 18 will be partially visible in the eastern United States. More on that in the November "Sky Reporter."

Stars and Planets At dusk, summer stars are still well up in the west, while autumn stars are high in the east and the south. A few hours later, the winter stars are previewing in the west.

Technically, only Jupiter is an evening star, appearing in the constellation Pisces. But you will see Mars rising later, directly below the Hyades in Taurus. Saturn rises about midnight, near the twin stars Castor and Pollux. The planets, however, are best this fall in the morning sky. Just before daybreak, they will be lined up from east to west across the southern sky: brilliant Venus in the east, Jupiter (second brightest) in the west, Saturn and Mars in between.

October 17: The moon is at apogee, farthest from earth, today, and Mercury ends its retrograde motion in the morning sky.

October 19: The bright object moving across the sky tonight near the moon is Jupiter.

October 20: Tonight's full moon is the hunter's moon.

October 20–22: Look for the Orionid meteors in the early morning sky. This shower reaches maximum (about 25 meteors per hour) on the morning of the 21st.

October 24: Mercury is at its greatest distance from the sun in the morning sky.

October 24–25: The bright reddish object near the moon these evenings is Mars.

October 26: Daylight Time ends today.

October 27–28: Saturn is seen near the moon after midnight.

October 31: Venus is near the moon at dawn.

November 1: The moon is at perigee, nearest earth.

November 3: A partial solar eclipse, not visible in the Northern Hemisphere, occurs today.

November 4: The weak Taurid meteors reach maximum.

November 6: Mars, rapidly approaching opposition from the sun, becomes stationary and begins its retrograde (westerly) motion.

November 7: Venus is now at its best position as a morning star.

November 13: The moon is at apogee.

November 14: Saturn begins its retrograde motion, taking it back toward Pollux, in Gemini.

November 15: Look for Jupiter near the moon tonight.

★ Hold the Star Map so the direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:20 p.m. on October 15; 9:20 p.m. on October 31; and 8:20 p.m. on November 15; but it can be used for an hour before and after those times.





The Great American Football Ritual

by William Arens

Each autumn our society's dreams symbolically come true on gridirons across the country

Lear. O, you sir, you! Come you hither, sir. Who am

I, sir?

Oswald. My lady's father.

Lear. "My lady's father"? My lord's knave, you whoreson dog, you slave, you

cur!

Lear.

Oswald. I am none of these, my lord; I beseech your par-

don.

Do you bandy looks with

me, you rascal? [Striking

him]
Oswald. I'll not be strucken, my

Kent. Nor tripped neither, you base football player.

King Lear. Act I, Scene 4.

The attitude toward the football player has obviously changed since Shakespeare's time. Today the once "base football player" occupies the hearts, minds, and television screens of millions. He is emulated and sought after, and the stratagems he uses in the game are often followed at the highest levels of government and business.

As an anthropologist I would contend that football, although only a game, tells us much about who and what we Americans are as a people.

This belief owes its impetus to the hundreds of football games I have watched on television. Feelings of guilt led me to muse in an academic fashion about the game and turned me to books written by players, as well as to the rare anthropological accounts of sport in other societies. This research has led me to believe that if an anthropologist from another planet visited here, he would be struck by the American fixation on this game and would report on it with the glee and romantic intoxication anthropologists normally reserve for the exotic rituals of a newly discovered tribe. This assertion is based on the theory that certain significant symbols are the key to understanding a culture; football is such a symbol.

This argument requires a short detour in time to examine the evolution of the game from its European origins. Mythology states that it was first played by a group of English soldiers who celebrated their victory over a Viking settlement by using the skulls of the dead enemy in a kicking match. Sometime later, an inflated animal bladder was substituted for the skull, and the sport became known as "Dane's head."

During the early Middle Ages, the game often took the form of a disorganized, all-day competition between neighboring towns. A ball was placed midway between two villages and the object was to kick it along the countryside to the opposing village green for a score. In the twelfth century the pastime became so popular with the English peasantry that Henry II banned it because it interfered with the practice of archery. The sport was not reinstated until the seventeenth century, by which time the longbow had become an obsolete weapon.

According to sociologists David Reisman and Reuel Denny, who have charted the game's evolution, kicking a ball remained a dominant part of the game until 1823 when, as popular legend has it, one William Ellis, of Rugby School, "with a fine disregard for the rules of football, as played in his time, first took the ball in his arms and ran with it. . ." This innovation became institutionalized at the school and shortly thereafter was adopted by others, hence the name Rugby.

In America, the honor of playing the first game of what was to emerge as football should go to Harvard and McGill, which in 1874 played a game that essentially followed Rugby regulations. In the remaining decades of the nineteenth century, the sport began to take on a more American form as a definite line of scrimmage and the center snap replaced the swaying "scrum" and "heel out" of English Rugby. This

Rene Burn, Magnum Pho









Erich Hartmann, Magnum



















meant that possession of the ball was now given to one team at a time. The introduction of the forward pass in the early years of this century, however, signaled the most radical break with the past. These revisions on Rugby not only resulted in greater structure and order, but they also provided more variety and flexibility since running, kicking, and forward passing were incorporated as offensive maneuvers.

Football has now emerged as an item of our cultural inventory that we share with no other country except Canada, where it is of minor interest. We share our language, kinship system, religions, political and economic institutions, and a variety of other traits with many nations, but our premier spectator sport remains ours alone. This is important when we consider that other societies have taken up baseball, which is derived from cricket, and basketball, a domestic product. Like English beer, the American brand of football is unexportable, even to the colonies.

Football, in contrast to our language and many of our values, was not forced upon us. We chose to accept it. Our society, like any other complex one, is divided by race, ethnicity, income, political affiliation, and regionalism. Yet 79 percent of all the households in the country tuned in the first Super Bowl on television, implying that the event cut through many of these divisive factors. The game does not represent Middle America, as is so often claimed, but rather the whole of America. A love of football is one of the few interests we share with few outside our borders, but with almost everyone within them.

The salient features of the game reflect some striking similarities to the society that created and nourished it. More than any other sport, football combines the qualities of group coordination through a complex division of labor with highly developed specialization. Every professional and major college team today includes a player whose only function is place-kicking, while another player is used only for punting. Individuals on some teams have the sole responsibility of centering, or holding the ball for the point after a touchdown. Football is also a game

where success now demands extensive reliance on sophisticated electronic technology—from telephones to computers—to relay instructions while the match is in progress. In short, football, as opposed to its ancestor, Rugby, epitomizes the spirit and form of contemporary American society.

Violence is one of our society's most obvious traits, and its expression in football, where bodily contact and territorial incursion are essential, clearly accounts for part of the game's appeal. It is hardly surprising, therefore, that books by participants are replete with symbolic references to war. Jerry Kramer, a Green Bay Packer during the 1960s and coauthor of Instant Replay, divides the book into the following sections: Preliminary Skirmishes, Basic Training, Mock Warfare, Armed Combat, War's End. And Frank Leahy, a former coach at Notre Dame wrote in his memoirs that "the Stars and Stripes have never taken second place on any battlefield. With this in mind, we ask you to think back and ask yourself where our young men developed the qualities that go to make up a good fighting man These traits are something that cannot be found in textbooks nor can they be learned in the lecture room. It is on the athletic fields that our boys acquire these winning ways that are as much a part of the American life as are freedom of speech and of the press."

Mike Holovak, a former coach with the New England Patriots, waxed even more lyrical in reminiscing on his World War II military service. He refers to those years as the time he was on "the first team" in the "South Pacific playground" where the tracers afced out "like a long touchdown pass" and the artillery fired "orange blobs—just like a football."

To single out violence as the sole or even primary reason for the game's popularity is a tempting oversimplification. Boxing, for example, allows for an even greater display of legitimate blood spilling. Yet boxing's popularity has waned over the last few decades, an indication, perhaps, that reliance on naked individual force has less appeal for us than aggression acted out in a

more tactical and sophisticated context. Football's violence is expressed within the framework of teamwork, specialization, mechanization, and variation, and this combination accounts for its appeal. But we cannot explain football's popularity on the basis of violence alone because we are not unique in this respect. There have been many other violent nations, but they did not enshrine football as a national symbol.

Although baseball—the national pastime—has not suffered the same fate as boxing, interest in this game has also ebbed. Like boxing, baseball is not in step with the times. Its action does not entail the degree of complexity, coordination, and specialization that now captures our fancy. The recent introduction of players who only bat or run bases, and who never field, are moves to inject specialization and heighten the game's appeal to modern America. Baseball, however, belongs to a past era when life was a bit less complicated.

While football, representing the typical American outlook, overshadows class, race, and economic differences in our society, it emphasizes the division between the sexes. The game is a male preserve that manifests and symbolizes both the physical and cultural values of masculinity. Entrance into the arena of football competition depends upon muscle power and speed, which only a very few males and probably no females possess. Women can and do excel in a variety of other sports, but football totally excludes them from participation.

In an informal game between females in a Long Island community, the husbands responded by appearing on the sidelines in women's clothes and wigs. The message was clear. If the women were going to act like men, then the men were going to transform themselves into women. These "rituals of rebellion" involving an inversion of sex roles have often been recorded by anthropologists. It is not surprising that this symbolic rebellion in our culture involved a bastion of male supremacy.

If this argument seems farfetched, consider the extent to which football gear accents the male physique. The donning of the required items results















in an enlarged head and shoulders and a narrowed waist, with the lower torso poured into skintight pants accented only by a metal codpiece. The result is not an expression but an exaggeration of maleness. Dressed in this manner, players can engage in hand holding, hugging, and bottom patting that would be disapproved of in any other context, but which is accepted on the gridiron without a second thought. Admittedly, there are good reasons for wearing the gear, but that does not mean that we should dismiss the symbolic significance of the visual impression. The game could just as easily be played without the major items such as the helmet, shoulder pads, and cleats. They are as much offensive as defensive in function. Indeed, in comparison, Rugby players seem to manage quite well in the flimsiest of uniforms.

Just as the players' uniforms symbolize exaggerated masculinity, their activities symbolize an aloofness from the profane business of everyday life. This is a common aspect of ritual behavior in any part of the world. Especially relevant for the participants in rituals is the avoidance of what anthropologists refer to as "pollution"—an impure ritual state—as the result of contact with contaminating acts or situations.

In many rituals performed entirely for and by males, sexual contact with females is avoided because it is considered an expression of man's animal, or profane, nature. In some societies, prior to an important activity such as hunting or warfare, community members are admonished to refrain from sexual behavior for fear of disastrous consequences. In the world of sport, and in football in particular, abstinence before a game is therefore not too surprising. In this context I am reminded of anthropologist E. Adamson Hoebel's statement, "The Cheyenne feeling about male sexuality is that it is something to be husbanded and kept in reserve as a source of strength for the great crises of war."

This attitude is common in football training camps. At these virtually monastic facilities, all the players, including married men, are sequestered during practice days. Since there is no practice on Sunday, players are allowed to visit their wives on Saturday nights. In consideration of Monday practice, however, players must return to the allmale atmosphere on Sunday evening. The result is that sex and football, the profane and the sacred, are segregated in time and space.

During the season a variation of the procedure prevails. Since the games are played on Sundays, the players and staff spend Saturday nights together. In each instance there is a clear-cut attempt to avoid the symbolic danger of contact with females prior to the event. This segregation was impressed on me when I traveled with my university's team by chartered bus to a game to be played at the opponent's field. Since there were a few unoccupied seats, two of the players asked the coach if their girl friends could ride along. He said in all seriousness that they would not be permitted on the bus with us, but that they could join us on the way home.

A writer who spent the season with the Rice University football squad mentioned a similar instance. When the bus pulled up in front of the dormitory on the opponent's campus where the team would spend the night, a number of the girls from the college entered the vehicle and began to flirt with the players. The Rice coach, who was in an accompanying car, stormed onto the bus and ordered the girls off immediately. He then told the players that they should have known better since the incident was a dirty trick instigated by the foe.

As another example, Jerry Kramer describes the night before the first Super Bowl, when the Green Bay Packers were allowed to bring their wives along as a reward for championship play. "My wife's been here for the past few days, and so has Chandler's. Tonight we're putting the girls in one room, and Danny and I are sharing one. It's better for the girls to be away from us tonight. We're always grumpy and grouchy before a game."

There are, of course, some perfectly reasonable arguments for segregating the players before a game. The coaches argue that the team members get an undistracted night's sleep and will thus be better able to

concentrate on the upcoming event.

The inhibition of sexual activity prior to an athletic event, however, has no apparent scientific rationale. The latest research argues that sex is actually beneficial since it induces a more restful night's sleep. A British physician who advised and interviewed his country's Olympic competitors mentioned that one informant admitted setting the world record in a middle distance track event an hour after sexual intercourse. Another athlete said that an hour and a half after the same activity, he ran the mile in less than four minutes. One must look beyond rationality for an explanation of the negative attitude toward sex on the part of the elders who control professional football. If we grant that the sport involves a significant ritual element, then the idea does make some sense. From this standpoint, scientific reasoning is not relevant.

Accounts of rituals in other cultures also indicate a prevalent belief in symbolic contamination through contact with illness or physical imperfection. Examples of this sort of avoidance also crop up in football. Players avoid and ridicule those who become sick to their stomachs in the summer heat of training camp.

In a similar vein participants are admonished to stay away from an injured player so that the trainer can attend to him. The players, however, do not appear to need the advice since after a momentary glance they studiously avoid a downed colleague. Injured, inactive players on the team I was associated with as faculty sponsor were not allowed to mingle with the active participants during the game. The loquacious professional Jerry Kramer also writes that when he was hurt and disabled, he felt like an "outsider," "isolated" and "separated" from the rest of the group. Others have written that they were ignored during these times by their teammates and coaches.

Eating is another profane act; as a further indication of our animal nature, it renders an individual unfit to participate in rituals. In contrast to sexuality and physical imperfection, however, nourishment cannot be avoided for any length of time. Instead, under controlled conditions,

the act of eating is incorporated into the ritual, and the food becomes charged with a sacred character. Not just any type of food is acceptable. What is more appropriate in our society then males eating beef prior to the great event? Imagine the scorn that would be heaped on a team if it were known that its members prepared themselves for the competition by eating chicken.

The problem with eating any meat on the day of the competition is that meat is not converted into potential energy until hours after the game has ended. Although the players must appear for this meal because it is part of the ritual, few actually eat what is presented to them. Instead, in contradiction to the ritual leaders. the participants prefer a high-energy snack, such as a pill, that has more immediate value. Nevertheless, as in the other instances, those who control the players' behavior adhere to a less functional course by forcing their charges to confront a symbolic substance. If this situation were presented to an anthropologist in the heart of the Amazon, I wonder how long it would take to suggest ritual cannibalism on the part of the natives.

A ritual has a variety of levels, components, and consequences. The slaughter of a white bull during a rite de passage for males among cattlekeeping people in Africa has an obvious nutritional benefit for those who consume it. At the same time, this does not obviate the ritual significance of the act. If I am making too much of the symbolic element of American football, then perhaps we ought to reconsider the ease with which we accept this type of analysis for other, supposedly simpler cultures. Accounts of team log-racing among the Shavante Indians of Brazil as an attempt to restore harmony to a social order beset by political divisions and the analysis of cockfighting in Bali as an expression of national character have caused little stir. Unless we consider ourselves something special, our own society is equally suitable grist for the anthropological mill. It is reasonable to suppose that if other people symbolically express their basic cultural themes in rituals, then we are likely to do the same.

Don McCullin, Magnum Pho

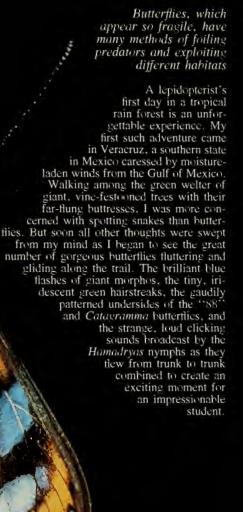




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Adaptation on the Wing

by Thomas C. Emmel







Thomas W Davies

The freshly laid eggs of the Baltimore checkerspot, left, will turn dark purple as the larvae develop. After hatching and molting, the caterpillars overwinter in a communal web. Caterpillars of the common grass yellow butterfly, above, chew Cassia leaves in a rain forest in New Guinea. Most caterpillars are prodigious feeders: some. at times, are cannibals.

Since that day I have visited many rain forests throughout the American tropics, and every trip reinforces my belief that here is the true paradise on earth for students of butterflies. No other life zone has butterflies so diverse in structure and behavior, so numerous and visible, or so important a part of the community of plant and animal life.

Tropical rain forests straddle the Equator in central Africa, the conti-

nental and island areas of Southeast Asia, the islands of the South Pacific, and northeastern Australia. But the most extensive rain forests of all spread a dense green carpet across Central and South America. These steaming jungles fascinated nineteenth-century European naturalists.

Such men as Charles Darwin, Henry Walter Bates, and Alfred Russel Wallace came to South America as young naturalists and left as seasoned biologists with a store of insights that would enrich the world. Darwin and Wallace in 1858 published their theories on the origin of species by natural selection and became famous. Less is known of Bates's contribution. In 1848, at age twenty-three, he set off with Wallace up the Amazon River to explore the natural history of Brazil. After traveling together for several years, they separated, but Bates stayed on in Brazil until 1859. He collected and sent back to England nearly 15,000 species of animals, mostly insects, of which more than 8,000 proved to be new to science. It is a record that will probably never be equaled. Bates's book. The Naturalist on the River Amazons, published in 1863, contained many of his observations on Neotropical butterflies. It proved an instant commercial success and stimulated a great interest in the natural history of the American tropics.

Aside from the large number of new species that Bates discovered, his most significant contribution was based on his observations of insect mimicry. While collecting on the lower reaches of the Amazon, Bates had noted uncanny resemblances in shapes, colors, and behavior between butterflies of very distinct families. He encountered many transparent-winged species of Ithomia butterflies floating in abundance in the shady ravines of the tropical forest. Now and then, flying among the Ithomia was a Dismorphia, also a clearwinged butterfly but one belonging to a totally different family, the Pieridae. Bates was unable to distinguish the two butterflies on the wing; each time he captured an Ithomia only to find it was a mimicking pierid, he could scarcely restrain an exclamation of surprise, so perfect was the mimicry in behavior, color pattern, and size. (It was later ascertained that



Gillett's checkerspot, left, is found only in isolated colonies on high mountains, where it exploits a microhabitat within a limited range.

ithomiids are protected by unpalatable secretions while the pierids are not.) This form of imitation has since come to be known as Batesian mimiery.

In 1859, after reading Darwin's Origin of Species, he saw that the most logical explanation was that an insect like Dismorphia improved its chances of survival by looking like a common unpalatable species. Bates concluded that the case offered a most beautiful proof of the theory of natural selection.

Fritz Müller came to the Brazilian Amazon a few years after Bates and discovered another important kind of mimicry among butterflies. While collecting ithomiids, Müller observed that a great many of these butterflies shared the same general color pattern, yet all of them were presumably unpalatable because their larvae fed on poisonous plants of the nightshade family. In his 1878 theory, which has become known as Müllerian mimicry, he suggested that sharing a common warning color pattern and common behavior was a survival advantage to each of the unpalatable species because predators learned to associate an unpleasant eating experience with that pattern; they had only to try one species of ithomiid to learn that eating it would produce such an unpleasant experience. Thereafter the predators would avoid all butterflies similar in appearance to the sampled one.

The tremendous variety of species

The overlapping scales on the wing of a swallowtail from New Guinea create a color pattern by absorbing and reflecting different wavelengths of light.

David Cavagnaro

Kjall B. Sandved





By feeding on the flowering plants in mountain meadows, the purple-edge copper has been able to colonize an alpine habitat 6,000 feet high.

in tropical regions has intrigued many biologists. Some indication of this variety is revealed in Bates's data. In all of South America (only partially collected even today), Bates became acquainted with 4,560 species of butterflies at a time when only 716 species were known to inhabit the entire Palaearctic region, from Europe to Manchuria, the best-studied area in the world. All of Europe contains only about 400 butterfly species, whereas within the radius of an hour's walk at Pará (now Belém), Brazil, Bates easily collected 700 species.

The conditions that have produced such sharply contrasting figures are not yet completely understood. Biologists have observed the stikingly brief period of development for tropical insects. The danaid butterfly Danaus chrysippus usually goes through only one generation a year in the northern parts of its range in Asia, but in the southern Philippines it has' a steady progression of generations throughout the year, each one taking only about three weeks to develop from egg to adult. The butterflies can accomplish this rapid turnover of generations because most tropical rain forests do not have well-defined seasons. Rainfall is a more-or-less constant quantity every month of the year, and the temperature range and length of day barely change. High temperatures and humidity, much light, and a great quantity of rapidly growing food make the tropics an ideal environment for cold-blooded butterflies. The additional generations possible over a certain period result in greater butterfly variation because more mutations can appear.

The biological environment of the tropical butterfly likewise contributes to creating diversity in these insects.

The tremendous variety of plants available as hosts for the larval stages allows a much greater range of specialization on particular plants than is possible in the temperate zones, so there are many more opportunities, or niches, for tropical butterflies to exploit. Many plant species grow to certain heights in the forest and form discernible "layers," from the topmost canopy to the herb layer at ground level. The stratification of flight activity in different layers of vegetation increases the specialization opportunities available for additional species of butterflies.

The vast number of predators in the tropics also greatly influences butterfly variety. In their struggle for survival, many butterflies have adapted such devices as extensive mimicry of each other or, particularly in their larval and pupal stages, imitation of inedible objects, such as leaves or bird droppings.

A number of physiological and behavioral traits that serve as survival mechanisms have developed in the eighty or so morpho butterfly species of the American tropics. These traits are interesting examples of the evolutionary diversity, compared to arctic or temperate species, that is characteristic of butterflies in tropical rain forest habitats.

The upper surfaces of morphos' wings are usually brightly colored, ranging from white to light blue to dazzling deep blue to purple, although several species lack iridescence and flit about in somber yellowspotted brown. The undersurfaces of all the species are brown, camouflaging them perfectly when they suddenly alight and fold their wings together. The slightly larger females are often less brilliant than their mates and have more retiring habits. Some, such as Morpho cypris and M. theseus, spend their lives in the treetops, while others, such as M. peleides, normally fly near the ground along paths and trails. Adults have been found to live close to nine months and apparently learn quite a bit about their environment. Many morphos follow regular flight routes during their daily movements through the rain forest.

In Central America, these flight paths apparently function as territories for male butterflies of *M. amathonte*. The male populations of this species form sleeping roosts consisting of a few individuals, which pass the night on top of large leaves within a few feet of each other. In the early morning hours, the males fly off to nearby feeding sites, which are accumulations of fermenting fruit on the forest floor. They usually feed between 7:30 and 9:30 A.M., without notably aggressive behavior. Females always feed after the males have left the fruits; thus no courtship occurs at the feeding sites. Between 9:30 A.M and noon the butterflies move along somewhat circular flight paths. At this time, the males-each flying its own daily patrol route—attract, court, and mate with the females. This territorial behavior spaces out the males and draws them into a regular flight schedule through the forest understory, while the iridescence of their wings helps to attract females from afar.

Early in the afternoon, before the usual daily rains begin, the morphos, particularly the males, return to the general area of the feeding sites and roost there for the night. This daily activity pattern probably prevents aggressive behavior among the males when they are crowded together at feeding sites and nocturnal roosts. Their large but fragile wings would soon be battered by fighting if courtship and mating took place where several males were on hand.

One question may come to mind. If a morpho flaunting conspicuous wing coloration to attract females passes the same point on a trail at about the same time each day, why do not predators watch these flight paths and catch all the morphos that come along? A number of longbeaked birds such as jacamars, flycatchers, and motmots feed on butterflies, including morphos that are brown on both sides of their wings. But the brilliant blue species do not seem to be attacked very often. They seldom have beak marks on their wings where a bird tried to seize them, and their wings are rarely found in the piles of insect remains on the forest floor under the perches of these birds. Predators may learn to ignore these bright and showy butterflies since they are exceedingly difficult to catch. When chased by a bird, a flying morpho can quickly alter its pattern and speed of flight by increas-



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ing its characteristic vertical bobbing. As its mirrorlike iridescent wings flash in the sun, the morpho's flight becomes even more confusing to a predator, thereby almost inevitably insuring the butterfly's escape. A bird quickly learns that it is unprofitable to hunt this flashing, bobbing beauty.

Another diverse Neotropical rain forest group comprises the ithomiid butterflies-the 400 or so species are characterized by a host of Batesian and Müllerian mimicry associations. The caterpillars feed on plants of the nightshade family, absorbing the poisonous alkaloids in the leaves. When passed along to the pupal and adult stages, these poisons continue to protect the butterfly against being eaten by a bird, lizard, or other predator. These butterflies, among other insects, may have evolved ways to detoxify the compounds they absorb, rendering them harmless to their own body tissues.

The life histories of the ithomiids have not been well studied, but those that have been traced reveal fascinating variations in the developmental stages between different species in this group. The larvae are often yellowish to green, with deeply creviced body segments; some resemble flattened species of common garden millipedes. Other larvae are cylindrical and encircled by blackand-white bands. In butterflies that lay clusters of eggs, the hatching larvae feed together as a group and move around communally for at least several instars, or stages between molts. Other species, which lay their eggs singly, share the solitary larval habits characteristic of most butterflies. The pupae of many ithomiids are a dazzling silver or gold, looking like large drops of forest dew or rainwater reflecting the morning sunlight.

All of the ithomiids exhibit a slow, fluttering flight, the slowest and weakest being that of the transparent-winged species. Because most of their wing scales have been reduced to hairs, leaving the membrane exposed, these ithomiids achieve a kind of transparency. Deep in the forest interior, moving over dark leaf litter in heavy shade, they are almost impossible to see or follow in flight. Many retain white marginal spots on their wings which may deflect a predator's attention from vital body

parts. Other ithomiids take an alternate course and assume bright warning colors that advertise their unpalatability to predators.

Somewhat similar to the ithomiids in appearance are the long-winged heliconians, found only in the New World. These butterflies have specialized in eating the 400 or so types of passionflowers in the tropical jungles. Wherever these colorful plants blossom—in the forest canopy, in clearings, or along roadsides—one or more of the eighty-odd species of heliconians are sure to be found. They are long-lived butterflies, some with life-spans up to six months, and like the ithomiids and morphos, they need to supplement their usual sugary nectar diet with nutritionally richer sources of nitrogen and vitamins.

The most advanced species in the genus Heliconius do not depend on accidental opportunities such as bird droppings but take advantage of a second nutritious component of the flowers they visit: the pollen. The Heliconius butterfly has a specially constructed tongue for collecting pollen. Nectar and enzymes regurgitated onto the pollen-laden tongue release free amino acids, which can then be sucked up and absorbed by the butterfly. These amino acids, the building blocks of proteins, are passed into the butterfly's tissues, and if it is a female, into her eggs.

Lawrence E. Gilbert, a lepidopterist at the University of Texas who has done considerable research with Heliconius, has found that adults of some species actually patrol a regular route each day between nectar and pollen sources over miles of forest, and that males of at least one species actively fight off other butterflies from the flowers selected for their daily early morning feeding.

Heliconians usually deposit their eggs on the very tips of the vine tendrils of passionflowers. Yellowish orange in color, these prominently placed eggs warn other females that this plant is already "taken." Thus a single vine does not become overloaded with caterpillars. At least one species of passionflower has orange tips on its vine tendrils, which could deceive a Heliconius female into thinking that the plant already has an egg on it. That particular passionflower vine may then escape being

fed upon by Heliconius caterpillars.

Unlike the richly populated rain forests of South America, those of Africa contain fewer butterfly species. The African continent south of the Sahara (including the island of Madagascar) has just over 2,600 described species (compared with over 6,000 for South America), and a leading specialist in African butterflies, Robert Carcasson, estimates that this figure represents about 85 percent of the true total.

A majority of Africa's species are found in the rain forests and mountains of west and central Africa. Although many coppers and other lycaenids occur in the grasslands of south Africa, and other specialized groups reside in the rugged mountain ranges, it is the rain forest forms that are most distinctive in tropical Africa, as compared to the faunas of other world regions. The remarkable variety of trees, climbing vines, and other vegetation provides a rich source of food for caterpillars, and as in the American tropics, the small seasonal changes in the wettest rain forests allow for continuous reproduction.

The current drier climate, along with the influence of human cultivation and the extensive burning of the plains, has reduced the rain forests and separated the remaining stands by long stretches of grassland and sparse thorn scrub. As their habitat has broken up over the past several thousand years, such butterflies as the Charaxes species of the wet forests have formed different geographic races. Apparently the butterflies are unable to move from one forest area to another because of differences in humidity and other conditions in the intervening territory.

Among the tropical nymphalids, one attractive butterfly that is remarkable for its seasonal changes in color is *Precis* (a relative of the North American buckeye), whose many species are common throughout the woodlands and forests of Africa. Each species may have several color forms flying during the course of a year. In the dry season, for instance, the adults of P. octavia are heavily marked with black areas and blue spots, which may blend with the deep shadows of the sere vegetation. The wet-season form is smaller and bright

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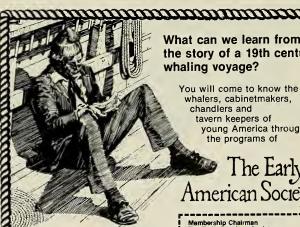
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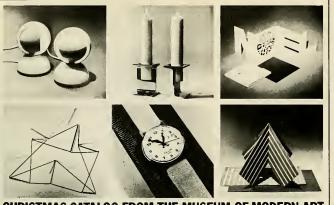
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orange with black markings. In P. pelarga populations, two dry-season forms appear. One is orange banded like the wet-season form, while the other has an intense blue band instead of orange. The wing margins of the dry-season forms in both Precis species are deeply scalloped and extended at the forewing tip and at the trailing edge of the hindwing. When the butterfly sits with folded wings among dead leaves, the false "stems" and the mottled browns and oranges on the underside make its resemblance to a leaf truly striking. Many of the satyrs also have seasonal forms, with more variable coloration and smaller eyespots appearing in the dry-season adults. All these changes in nymphalids and satyrs presumably aid in concealing the adult at a time when many plants in seasonal forest areas have lost their foliage and predators are avidly searching for food among reduced insect populations.

The largest butterfly on the African continent, the tailless swallowtail Papilio antimachus, is a rain forest inhabitant with an orange and reddish brown coloration bearing black markings. Males will occasionally visit mud at the edge of a forest stream, but their huge wingspan (more than nine inches) swiftly carries them away from danger if a predator appears. Many of the other Papilionidae have tails, which may aid in deflecting a bird's attack to this nonvital part of the hindwing. All are strong fliers, keeping to the forest or woodlands and often sailing high overhead among the canopy blossoms, with only an infrequent dip to a wet bank or understory flower.

One species has the common name of mocker swallowtail (Papilio dardanus) because many of the females mimic a wide variety of unpalatable butterflies. More than a dozen color forms are known, ranging from black and white, black and yellow, black and orange, and white and orange to nearly all black. The females of this mimetic species have even lost their tails, except in the races found in Ethiopia and Madagascar, where they are tailed like the creamy yellow male. This extensive mimicry in the females probably became established because it allows larger numbers of the swallowtails to live in the same area. In Batesian mimicry assem-

blages, where edible butterflies imitate poisonous species, the mimic must usually be less abundant than the unpalatable model or else the predators will often try a mimic and associate its appearance with edibility. Mocker swallowtail females solve this dilemma by looking like several different species or subspecies of poisonous butterflies in a given region and thus parceling out the mimetic advantage over a number of color forms instead of one.

The remarkable family Acraeidae reaches its fullest diversity in the forest and savannas of central Africa. Acraea encedon in east and west Africa occurs in almost exclusively female communities in certain cultivated areas, an extraordinary situation that appears to be part of the way this species regulates its population. This is also one of the most varied butterfly species in Africa with as many as ten or more color forms. Four match the four African forms of the golden danaid Danaus chrysippus, a butterfly that has proved unpalatable to birds in feeding experi-

Other Acraea species resemble each other, and many nymphalids seem to mimic acraeids. The complexities of these mimetic associations are great, and it is often not clear as to which species are the models and which are the mimics or just coincidentally similar in color pattern. Certain acraeine caterpillars feed on passionflowers, some of which are known to contain toxic compounds. Others, like A. encedon, apparently feed on nontoxic plants, or perhaps these butterflies do not derive the toxic compounds from plants but produce them metabolically.

The acraeids and their many mimics, along with Papilio dardanus and its diverse mimetic female forms. are providing key material to geneticists and students of ecology in unlocking the secrets of complex evolutionary histories. Combined with similar studies of New World butterflies, a deeper understanding of how plant and animal communities have coevolved is emerging. For a lepidopterist such as myself, that is reward enough, and the flash of a brilliant wing against the green jungle canopy adds a delightful dividend to the pursuit of butterflies

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Techniques of Ancient Skull Surgery

by Richard G. Wilkinson

The evidence suggests that jewelers in Monte Albán tried out new types of drills on the heads of human guinea pigs

Primitive surgery has a peculiar fascination for most of us. We can picture the agony of the patient subjected to a flint or obsidian knife. Such an interest in surgery includes a special concern with surgery of the skull and its contents. Our relatively recent awareness of the tremendous complexity of the brain and its functions gives neurosurgery a particular place in our subjective hierarchy of surgical specialties.

If we accord to modern neuro-

surgery a certain awe, primitive and prehistoric skull surgery also demands our attention; not only was it practiced with great frequency in some areas of the world, but it was also surprisingly successful.

Trephination, or trepanation-in which an opening is made in the cranium-is best known prehistorically from western Europe and the highlands of Peru and Bolivia. The hole is frequently large, and relieving pressure is only one of its many functions. Thousands of trephined skulls have been recovered from these areas in the past 100 years and have provided valuable information on the causes, techniques, and successes of prehistoric skull surgery.

Recent archeological research in

the southern highlands of Mexico has pointed to the existence of another center of skull surgery in the prehistoric New World. Although certainly not of the same magnitude as the evidence from the Peruvian center, the Mexican material does point to an independent development of trephination and may indicate the existence of surgical experimenta-

The trephined skulls were recovered from Monte Albán, a huge urban and ceremonial complex in the center of the Valley of Oaxaca, on the western edge of the modern city of Oaxaca. The site was occupied for approximately 1,200 years, from 500 B.C. to about A.D. 700, and became one of the most spectacular



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centers of prehistoric civilization in the New World before its sudden and unexplained abandonment.

The main plaza at Monte Albán, consisting of monumental architecture, tombs, a ball court, and engraved figures, to name just a few of the more obvious features, was excavated and reconstructed during the 1930s and 1940s under the direction of Alfonso Caso. The subsequent analysis of the materials resulted in the designation of a series of five archeological periods, corresponding primarily to changes in the ceramics. The third period in the sequence, subdivided into periods IIIA and IIIB, ca. A.D. 200-700, represents the maximum development of the site as a combination ceremonial, economic, and population center.

Caso's excavations from the IIIB level alone yielded a large quantity of skeletal material, including seventy-three tombs and fifty-eight burials with pottery. Skulls of five individuals bore evidence of trephination, a practice thought to be rare north of the Peruvian area. These five skulls are extremely important to our ideas about skull surgery. Three of them have holes that were made by combined scraping and cutting away of the bone, presumably with an obsidian knife. The openings produced by this technique have beveled edges and are normally elliptical in shape. The same technique, sometimes with slight variations, was used in the western European and Peruvian areas as well and is by far the most common prehistoric trephining technique.

The other two skulls have holes that were made by drilling. These holes are characterized by their uniform circularity and vertical walls. One of these skulls provides consid-

Until trephined skulls were discovered at Monte Albán, archeologists had assumed that the practice in the Americas was limited to the Andes.

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erable evidence of the technique employed. This skull, actually a fragment of the cranial vault, has a complete, circular hole near the junction of the sutures at the apex of the head; next to this hole is a circular groove—an unfinished trephination. A hollow drill very similar to the modern trephine was evidently used to drill the skulls. The Monte Albán skulls appear to be the only prehistoric examples of trephining by drilling yet known.

In the fall of 1972, Marcus Winter of the Instituto Nacional de Antropología y Historía excavated a residential area less than a mile from the main plaza at Monte Alban. The excavations revealed continuous occupation from level I through level IIIB and contained the remains of houses, patios, ovens, and other residential material, as well as the skeletal remains of twenty-five individuals. One of these individuals, a male who died at about thirty-five years of age, had been subjected to skull surgery. The posterior portion of the right parietal bone has four holes in it, all of them circular in outline. Three of the holes are continuous, forming a single, threelobed opening, while the fourth is separated from the others by a thin section of bone.

Surrounding the holes is a triangular area of bone that is considerably rougher in appearance than the bone in other areas of the skull. The roughened area is bordered on the right side and the bottom by faint scratches or cuts in the bone. This roughened area represents infection, chemical reaction, or death of the bone. The circularity of the openings and their vertical walls point to the use of the hollow drill. Two of these holes have exactly the same diameter, about one-half inch, suggesting that both were made during the same operation with the same drill. The difference in appearance of the two other holes suggests that they were made during a second operation, probably the one that ultimately proved fatal.

The discovery of this skull increased the number of trephined skulls to six, and showed a greater use of the rare drilling technique. While six examples is a modest sample, I nevertheless began to wonder if Monte Albán might, in fact, represent the main area of Mesoamerican skull surgery.

There supposedly were seven



Bichard G. Wilkinson



Most trephinations were done by scraping away bone. In the upper skull, the rough edges of the right-hand hole indicate both infection and healing. The other hole shows no such signs and suggests that the patient died during the operation. The completed hole in the lower skull was made with a hollow drill. The second, unfinished hole suggests that this patient also died.

other trephined skulls from other parts of Mexico, which at first inspection seemed to diminish the rarity of the Monte Albán examples. It turned out, however, that two of them from southern Chihuahua were in all likelihood not prehistoric; they were described as containing "fatty matter" and had a distinctive odor.

Three other possible examples have been described from the Tlatilco site in the Valley of Mexico. Of these, two are definitely not trephinations—one hole appears to be a puncture wound and the other appears to have been drilled after death. The third example from Tlatilco is also suspect, considering the nature of the other two and the rarity of trephination in general. The remaining two skulls do in fact appear to be trephinations, although they may well have been trephined after death.

This information obviously increases the interest in the Monte Albán skulls, which appear more and more unusual. Fortunately, from my

point of view, the six skulls from Monte Albán were not the last to be found.

In 1973, excavations at the same residential area produced an additional fifteen skeletons. Four skulls in this collection had been trephined. Interred in adjacent graves, which had been lined and roofed with stone slabs, these four individuals had been buried on their backs with heads to the south. Two of the four were in their mid-twenties at the time of death: the other two were more than forty years old. A male and a female represented each age group, and the older male and female each had a large ceramic vessel inverted over their heads.

The skulls of the two young adults had been artificially deformed-vertically flattened in the rear by the pressure of a board secured to the head by a strap. The pressure of the strap had caused a horizontal depression across the forehead. The result was that the skulls were shortened from front to back and expanded on the sides. All of the more recently discovered trephined skulls from Monte Albán exhibit deformation in varying degrees, but the presence of many deformed skulls with no trephinations and trephined skulls with very slight deformation rules out deformation as a motive for the surgery.

The trephinations in the young adults were made by identical techniques and occur in the same areas in both skulls. The holes are at the apex of the skulls, the female having one trephination on the right side of the midline, in the parietal bone, and the male having two trephinations, one in each parietal. The hole in the left parietal of the male skull and the single opening in the female skull had been made by carefully cutting and scraping away the outer bone layer and the underlying diploic bone, leaving the thin inner table. This layer was then perforated, and a thin shelf of bone of the inner table remained around the opening.

Careful inspection reveals tiny scratches on this thin shelf of bone, as well as on the beveled edge of the original, larger hole. The scratches are also apparent on the outer table of bone around the hole in the left parietal of the male. The scratches, probably made by the trephining instrument, form a clockwise pattern, an indication that the surgeon was probably right-handed.

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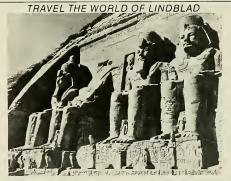
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On the left edge of the trephination in the female skull is a large area of infection or necrosis (localized tissue death). Since there is no evidence of healing along the rest of the margin of the opening, it appears that this bone destruction may have been the reason for the operation.

While the opening in the left parietal of the male skull is virtually identical to that in the female, the hole in the right parietal is somewhat different in its over-all appearance. Here the edges show some postoperative changes, which indicate that this trephination was the first of the two operations. The second hole, in the left parietal bone, suggests that the second operation was fatal. Multiple operations were common at Monte Albán, and it appears that as many as eight of the ten individuals survived at least one operation if only for a few weeks:

Much of the facial skeleton and part of the frontal bone of the older female had been destroyed by insects. The destruction included the front portion of the trephination in the left parietal bone. Nevertheless, the opening in this skull was made by scraping and cutting and generally resembles the hole in the right parietal of the young adult male. The edges of the hole are beveled and fairly rough in appearance, suggesting that the woman may have lived for a short time following the trephination.

The last burial, that of an older male, was probably associated with the older female, in that both are of about the same age and both had the same type of large pot inverted over their heads when they were interred. The skull of the old male had been trephined five times, and it appears that the patient survived the first four operations. Judging from the amount of apparent healing, the operations were begun in the rear of the skull, and progressed forward along the midline. A very small, well-healed opening made by the scraping-cutting method in the back portion of the left parietal bone was probably the first operation.

The same technique was used in the next three operations, differing from the operations in the other skulls in that the openings are elongated from front to back. As the operations progressed from the rear to the top of the skull, they also increased in size.

The largest and last opening, at

the top of the skull, was made by scraping away a large section of bone, using the same technique that had proved successful in the previous three operations. The right edge of this hole shows a slight degree of pitting, indicating that infection may have been setting in, which in turn is evidence that the patient survived the operation, at least for a short time. The outline of the left side of the opening is irregular and has a series of four semicircular impressions. These were most likely made by a drill, and the absence of healing evidence suggests that the drilling technique once again proved unsuccessful.

The discovery of these four individuals strongly supports my earlier impression that Monte Albán represented a unique center of prehistoric skull surgery in Mesoamerica, and the variety of techniques seen reaffirms the suspicion that the surgeons experimented with different methods. The accumulation of ten trephined skulls also allows for examination of sociocultural evidence associated with the skulls and suggests avenues of explanation of why the operations were performed.

Of the forty skeletons found in the small residential site, five were adults associated with the smallest variety of period IIIB houses; these are the only IIIB adults found at the site, and all five have trephined skulls. All five were oriented along the north-south axis, and all were extended on their backs. Three of the five had simple, utilitarian ceramic vessels with them, while the other two had no grave goods. The indication is that all five patients may have been individuals of low status. The four adults buried together may be paired, in that the older male and female had pots over their heads, had a slight degree of artificial deformation, and were of the same general age; while the two younger adults had marked deformation, no pottery, and their trephinations were identical in technique and location. Since the pairs consist of a male and female, it is more than likely that the relationship is one of marriage rather than consanguinity.

Considering all of the similarities in the five skeletons found at the residential area, questions were raised about the five trephined skulls from the earlier excavations at Monte Albán. All of them are of adults from the IIIB period. Four of

these burials included the entire skeletons, but one was only a skull covered by a large ceramic vessel. Of the four skeletons, three were extended and one was flexed, and three of the four had the same north-south orientation of the more recent discoveries. Three of the five burials were without grave goods, while two were buried with the same simple pottery of the later burials. It is clear that all ten patients belonged to the same status group, presumably the lowest, and that trephination at Monte Albán was restricted to a single cultural period and narrow time span, roughly A.D. 400 to 700.

I have suggested that these ten individuals may have been subjected to surgical experimentation. The techniques used are of two general types—cutting and scraping with flint or obsidian knives and drilling with hollow drills. Cutting and scraping techniques are common wherever trephination occurs, but there is no evidence that these procedures were derived from other areas of the world where trephination was practiced.

The drilling technique is found only at Monte Albán, and was most likely derived from jewelry making and dental mutilation practices. Teeth were often embellished with semiprecious stones inserted into small, circular holes, which were made by a hollow drill, most likely a length of bone or cane. An abrasive, such as sand or obsidian dust, could have provided the drill with a biting edge. Evidence has been found at Monte Albán of both jewelry and tooth adornment accomplished through drilling. Both of these occur earlier than skull drilling and thus represent logical antecedents.

It is abundantly clear from my own furtive attempts at drilling a skull with a bamboo drill that the surgeons at Monte Albán were skilled practitioners. A major problem is getting the hole started; the drill has a distinct tendency to slide on the surface of the skull. One imagines the problem to have been even worse when the drill was applied to the enamel of the central incisor teeth during dental mutilation practices.

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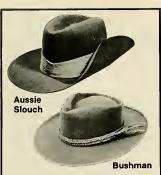
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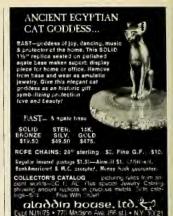
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between the palms of the hands also increases the undesirable wandering of the tip of the drill, and the force that can be applied with this technique is limited. I would imagine, then, that a bow drill was probably used, allowing relatively high speed and considerable force. Regardless of the actual technique used, one thing seems clear: it was done by true craftsmen who had extensive experience with drilling. I would speculate further that the surgeons were also the local jewelers and dental decorators.

In addition to such technical experimentation, the discovery that all ten patients belonged to the same low status group suggests the possibility of experimentation of a more discomforting type. Were the surgeons of Monte Albán using their lower-class neighbors as human guinea pigs or were these people simply more prone to cranial injury? There are a number of considerations that bear on these questions and they revolve around the question of why trephination was practiced in other parts of the world. Evidence relevant to the causes of trephination comes indirectly from the archeological record and from relatively modern observations of primitive skull surgery. Many of the prehistoric trephined skulls from Peru and Europe, especially the latter, indicate trauma, usually skull fracture. Not surprisingly, there is a fairly high correlation between frequency of trephination and evidence of weapons of the smashing variety, as opposed to cutting and slashing implements. Trephination in such cases was directly therapeutic-to remove bone splinters and relieve pressure.

Similarly, reports of recent primitive skull surgery from Africa, Melanesia, and Bolivia indicate that skull fracture and headache precipitated by trauma are common events leading to skull surgery. The most spectacular of these recent cases involves a Kinsii tribesman of Kenya who complained of headaches after a blow on his head. He was trephined an unknown number of times in subsequent years, until virtually all of the top of his skull was removed. It is not clear whether his headaches were cured, but he did survive these numerous ordeals.

Trauma or possible disease is evident in only four of the ten skulls from Monte Albán, and it is therefore difficult to demonstrate the



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presence of physical reasons for the operations. Evidence of warfare is generally lacking, and six of the trephined skulls belonged to females, which argues further against battle injuries as the cause of the trephinations. The lack of firm evidence for a natural cause for the operations in at least six of the ten individuals and, more importantly, the discovery of the four adjacent burials in 1973 suggest the possibility of the operations being performed for magical or religious reasons, in addition to possible therapeutic purposes.

We can speculate that the decline and fall of the civilization at Monte Albán was precipitated by epidemic disease, malnutrition, or a variety of health-related factors, and that skull surgery was an attempt to cure and prevent symptoms. But the complexity of environmental and cultural factors and their crucial influence on the decline of a civilization make the effects of poor health on such a decline extremely difficult to demonstrate, even with large skeletal samples. The small sample of skulls, however, makes any speculation hazardous, especially since those few skeletons I have seen are not particularly pathological. The future examination of additional skeletal material from Monte Albán may shed some light on the role of disease in the decline of the Monte Albán civilization, but until that time we should view the association of trephination and the abandonment of the site as a coincidence, albeit a suspicious one.

Viewing a group of trephined skulls with the knowledge that the operations took place 1,300 years ago arouses questions about the operating process itself and the suffering of the patients. The prehistoric trephinations of the Peruvian highlands were most likely performed using coca as the major anesthetic, and in several of the recent primitive examples, alcohol served the same purpose. No such use of anesthetics is definitely known from the prehistoric Valley of Oaxaca. Given the extensive native knowledge of herbal medicine, however, we can assume that the ancient inhabitants of Monte Albán also were capable of administering a natural drug to ease the pain.

Both the drilling and scraping away of the inner table of bone would require an immobile patient, and it is unreasonable to assume that the surgeon's assistants could hold

the patient still enough. Consider also that many of these people underwent a second operation, often a few days after the first, and in the same area, where the scalp would be tender, to say the least.

Lacerations of the scalp are noted for the quantity of blood spilled; how these prehistoric surgeons controlled the bleeding is an intriguing question. In the absence of any evidence, we can speculate that assistants were called upon to apply pressure to the severed blood vessels or that the vessels were cauterized. Considering that the majority of the skulls from Monte Albán reveal some signs of postoperative survival, infection must have been yet another problem to overcome. Most of the skulls show some pitting, roughening, or other indications of bone destruction, but we cannot readily determine the cause. If native medicines in the form of poultices were not available, survival would be short. Again it is probably unreasonable to suppose that these people did not have such herbal medicines, especially considering their technological achievements in other areas.

One other concern we have when we contemplate prehistoric surgery is the rate of success, measured by indications of bone healing and scarring as opposed to signs of infection or necrosis. Based on such evidence, most prehistoric trephination was successful, with 60 to 80 percent of skulls from some areas showing healing evidence. Such a success ratio was far better than that achieved by European surgeons of the eighteenth and nineteenth centuries, which may account for their refusal to accept the existence of prehistoric trephination.

At Monte Albán the old adage, "the operation was a success but the patient died," seems most apt. Only two of the ten patients seem to have survived for more than a few days or weeks, and one of these died during or shortly after his fifth operation. Eight of the skulls show some form of postsurgical bone reaction, hence survival, but survival was short. The Monte Albán surgeons evidently kept after their patients until they finally died. This would support the idea that the surgery was experimental, but death might also have been due to general incompetence of the surgeons, poor health of the patients, or any number of still undiscovered factors.



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From Big Bang to Eternity?

Gravity may not be strong enough to keep the universe from expanding forever

From ancient times until only half a century ago, the prevailing cosmological belief was that the universe must be unchanging. Then came the fundamental astronomical discovery that the universe is expanding, followed shortly by theoretical indications that the expansion started billions of years ago from an explosive Big Bang. Recent research sheds new light on the key cosmological question about the distant future: Will the universe expand forever or will it eventually revert to a contraction that ends in an apocalyptic "big crunch?'

Our own galaxy, the Milky Way, has about one hundred billion stars, among them the sun, and beyond our galaxy are uncounted billions of others. When the starlight from a distant galaxy is spread out into a spectrum, it shows features characteristic of stars in the Milky Way, but shifted to the longer wavelengths at the red end of the spectrum. This red shift is interpreted as being an example of the familiar Doppler effect whereby the pitch of a sound drops—that is, its wavelength increases-when the source is moving away from the listener. By analogy, we infer that distant galaxies are moving away from ours. Moreover, the amount of red shift has been found to be greatest for the most distant galaxies. A pattern in these observations indicated that speeds of recession of galaxies are proportional to their distances from us. The more distant a galaxy, the

faster it moves. This relationship, discovered by the great American astronomer Edwin Hubble in the 1920s, is known as Hubble's law. The ratio of speed to distance is currently estimated to be about 10,000 miles per second per billion light-years.

Hubble's law at first suggests the anti-Copernican notion that our galaxy is at the center of the universe, but a more acceptable interpretation is that the whole universe is expanding uniformly, that it has no "center," and astronomers in any galaxy would see the others moving away at speeds proportional to their distances. The situation can be pictured with the popular analogy in which galaxies are represented as dots on a balloon that is being blown up: as the balloon expands, each dot moves relative to all the others in obevance with Hubble's law.

A dramatic conclusion follows from Hubble's discovery. At some time in the past, all the galaxies must have been twice as close together as they are now; at some even more remote time, they must have been 100 times closer-at which point they would have been intermingling so that separate galaxies could not have existed. Earlier still, the material of galaxies would have been still more condensed, and so forth. There is no limit to this increase of density until we get back to a time, ten to twenty billion years ago, when every particle in the universe was infinitesimally close to every other. That was the moment of beginning, when according to most theorists, a gigantic explosion—the Big Bang—took place. It is not clear what it means to talk about conditions before that beginning, but the universe in its first few minutes after the Big Bang is believed to have been an enormously dense mixture of subatomic particles, atomic nuclei, and hot radiation. From this primordial fireball, the universe has been expanding ever since, to lower and lower densities and cooler and cooler temperatures. (Of course, while the average density has been steadily decreasing due to the expansion, there are regions of the universe where matter has collected again into galaxies and stars.)

What of the future? Will the expansion go on forever? To answer this question, we must consider the forces that act over very great distances and so affect the rate of expansion. Physics tells us that the most effective force on such a scale is gravity. Since gravitation acts as an attraction between all the pieces of matter in the universe, it will inevitably cause the expansion to slow down. According to Einstein's general theory of relativity, this eventuality leads to two possible alternatives for the future.

In one projection, if the average density of matter in the universe is great enough, the mutual gravitational attraction between bodies will eventually slow the expansion to a halt. The universe will then contract and finally collapse into a hot fireball like the globule of matter from which it emerged. It has also been suggested that the universe might "bounce" and begin a new era of expansion with a new Big Bang of the compressed matter. In that manner the universe could go on cycli-



cally forever, oscillating between expansion and contraction. However, despite widespread acceptance of the original Big Bang, there is no known physical mechanism that explains it and that could reverse a catastrophic big crunch. Apparently, if the universe becomes dense enough, it is in for a hot death.

But if the universe has a low density, its death will be cold. It will expand forever, at a slower and slower rate. Galaxies, in time, will turn all of their residual gas into stars, and the stars will burn out. Our own sun will become a cold, dead remnant, floating among the corpses of other stars in an increasingly iso-

lated Milky Way.

To decide which kind of future is in store, we should first measure the density of the universe and compare the result with the so-called critical value, above which gravity will eventually reverse the expansion. The most direct approach is to add up the masses of all the galaxies in a large volume of space and see what average density they give. This is not completely accurate because one has to assess how much "hidden" matter galaxies contain in addition to their visible stars. Densities of between about 2 percent and 30 percent of the critical value are derived by different workers, with a typical "best guess" at 5 percent to 10 percent. Although lingering uncertainties mean that the answer is not conclusive, this approach indicates that there probably is not enough matter in the universe to reverse the expansion.

The density can also be estimated indirectly from the abundances of

COSTUMES OF THE EAST, by Walter A. Fairservis, Jr., shows the great variety of exotic, romantic garments worn by the peoples of Asia, from the Middle East to China, from Lapland to Japan. Cultural and geographic aspects of the clothing are discussed, and beautiful color plates and black and white drawings show the rich detail of the costumes. Anthropologists, clothes designers, and devotees of Oriental art will appreciate the value of this book both as a reference and for sheer pleasure. Cloth \$15.00, paper \$5.95

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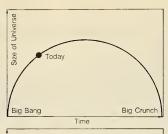
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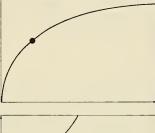
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some chemical elements believed to have been made by nuclear reactions in the minutes following the Big Bang. The abundances disclose the density of interacting particles when the universe began, which can be scaled down in a known way to give the present average density of the universe. This approach also shows that the density is probably only about 5 percent to 10 percent of the critical value.

A different way of calculating the future of the universe is to try to determine its rate of deceleration, or slowing down, which can then be compared with a "critical" minimum rate needed if the expansion is headed for reversal. One method of measuring deceleration assumes that if the expansion speeds of the galaxies had always been constant, the ratio of speed to distance in Hubble's law would mean that the Big Bang occurred twenty billion years ago; but if speeds have decelerated, the Big Bang must have occurred more recently. The oldest stars are thought to be twelve to sixteen billion years old, which, compared with twenty billion years, limits the amount of deceleration to a value less than the critical minimum. The present rate of expansion and the ages of stars are not known accurately enough for this estimate to be decisive—it is, however, consistent with our conclusions based on density.

Finally, it may be possible to determine the past expansion rate fairly directly. The speeds, or red shifts, of galaxies can be measured out to distances of about eight billion light-years, which means that we are actually observing the rate of expansion of eight billion years ago, when the light left the galaxies. Galaxies far enough away for the difference between present and past expansion rates to be detectable should have greater red shifts than predicted by Hubble's law, and the excess gives a measure of the deceleration. The chief problem with this approach lies in determining the distances of the galaxies from the earth. It has been found best to use their apparent luminosities for this purpose, but there are serious practical and theoretical difficulties in measuring the luminosities of far distant galaxies and then effectively converting those brightnesses to distances. For example, we have to calculate by how much the intrinsic luminosities of galaxies have diminished owing to







the evolution of their stars over the past eight billion years. The best that might be hoped for is that the attempt to measure the past expansion rate would give results consistent with the other computations—a small deceleration, predictably caused by a density of matter much less than critical. Until recently, that was indeed a credible interpretation of the data.

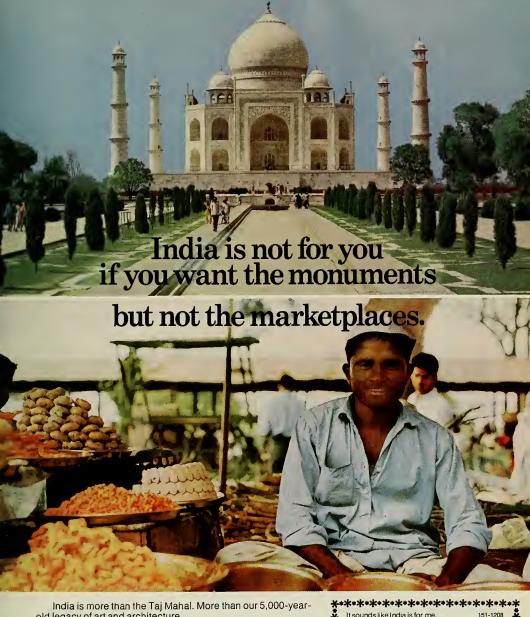
But the latest and most precise results have surprised us. They seem to show that distant galaxies have red shifts smaller than the Hubble law values, implying that the past expansion was slower than the present rate. In other words, expansion seems to be accelerating. This is very disturbing because it was fundamental theoretical prediction that the ubiquitous effects of gravity must cause deceleration. One way out of the dilemma might be to go back and look for systematic errors in our interpretation of the data; for instance, if we found that the galaxies are closer to the earth than our current estimates allow, their red shifts might no longer seem too small. A more exciting possibility is to accept the results at face value (while still studying the mundane possibility of

The density of matter in the universe is a crucial factor in predicting the future of the cosmos. Assuming the universe began with a Big Bang (which also marked the beginning of time) and has been expanding ever since, there are three possibilities. According to the first (top figure), the density of the universe is greater than the critical value required to halt expansion. Gravitational attraction therefore reverses expansion and the universe contracts and eventually collapses. In the second case (middle figure), the density is less than critical so the universe expands forever, but at an ever slower rate. In the third case (bottom figure), the universe also expands forever, at a decelerating rate at first because of gravity and then at an accelerating rate because of a force of cosmic repulsion.

errors, of course) and postulate that some force of repulsion is, in fact, predominant over gravitational attraction on the cosmological scale.

It is fascinating to note that Einstein himself once believed that such a force must exist, simply because in the days before cosmic expansion was recognized, he assumed that the universe must be static; a force of repulsion was therefore needed to balance that of gravity. Perhaps we will return to something similar to Einstein's former idea. With a slightly different value for the repulsive effect than that assigned by Einstein, a force of repulsion could account for the universe starting with infinitely rapid expansion following the Big Bang, then slowing down, and eventually, when the density became so small that cosmic repulsion won out over gravitational attraction, starting to accelerate. If this should prove to be the correct interpretation of the data, the pull of gravity will never be preeminent again, and we can be sure that the universe will expand forever.

Astrophysicist Beatrice M. Tinsley, who was born in England, teaches astronomy at Yale University.



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The Gifts of the Goat

Milk, yogurt, cheese—and a warm sweater—are just a few of this maligned beast's hounties

Goats are the black sheep of the barnyard world. They get short shrift from most people, who fall without thinking into the age-old tradition of abusing goats, of calling them filthy and randy and mean. It surely is enough to get your goat, this arrogant scapegoating of the genus Capra. Yet there is probably nothing that can be done to overcome this widespread and capricious antipathy. It goes back at least as far as the Romans, who said "goat" when they meant BO. Even Jesus preached that the "Son of man" would choose between good and evil nations "as a shepherd divideth his sheep from the goats."

Familiarity apparently does breed

contempt. Goats are the oldest domesticated ruminants. They have been giving their milk to men since prehistoric times. But they have long since been almost totally supplanted as milk sources by cows, which have more tranquil natures and more grandiose mammary units. Billy goats, nanny goats, and their nimble, frisky kids have been left to eat tin cans (for the labels, not the metal) and strip shrubs (goats are browsers,



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not grazers) that could not support dairy cows or beef stock.

Goats, you see, are survivors. Unlike sheep, both the males and females of most species of goats have horns, which may be why 400 million goats flourish everywhere in the world except the polar regions. Lightweight and resourceful, goats are so numerous that they contribute to soil erosion and the expansion of the desert in some countries where they have been allowed to crop indiscriminately at vegetation.

In the United States, there are three million goats, more or less. The vast majority coexist with cattle on Texas ranges, gobbling what their bulkier fellow Bovidae will not or cannot stomach and producing mohair wool in return. These are Angora goats, and like their Cashmere cousins in Asia, they have the good luck to produce a cash crop. In the United States the common goat (Capra hircus) and the four varieties of thoroughbred milk goats (Nubian, Saanen, Alpine, and Toggenburg) are mainly raised as pets or as sources of

Pig

Porpoise

Reindeer

Rabbit

Seal

Whale

Zebu

80.63

41.28

68.50

63.38

34.00

69.80

86.20

meat and milk for the farmer's family.

At least one American farmer has, however, turned goat dairying into a large business. William C. Wagner of Boyertown, Pennsylvania, north of Philadelphia, is currently presiding over a small renaissance of interest in goat milk and goat ice cream and goat yogurt. His company, Pure Goat Products, distributes these esoteric items in health food and gourmet shops and through some conventional dairy retailers from Massachusetts to Florida. In fact, Wagner says he is almost at the point where he will have trouble finding enough whole goat milk for his excellent goat cheddar and buttermilk. Although this certainly does not mean that goats are about to give cows a run for their money in the American milk market (over 100 billion pounds produced annually), the goat boomlet does make it fairly easy for you to sample milk products from a new mammalian source.

Goat's milk is, of course, only one of many "alternative" milks. Perhaps some day a Florida entre-

Cow	87.29	3.42	3.66	4.92	0.71
Goat	87.33	3.50	4.15	4.20	0.82
Human	87.60	1.20	3.80	7.00	0.21
Ass	89.08	1.98	2.45	6.04	0.45
Buffalo	82.44	4.74	7.40	4.64	0.78
Camel	87.67	3.45	3.02	5.15	0.71
Cat	83.05	7.00	4.50	4.85	0.60
Dog	74.55	3.15	10.20	11.30	0.80
Elephant	85.63	3.20	3.12	7.42	0.63
Fox	81.86	6.35	6.25	4.23	1.31
Horse	89.18	2.60	1.59	6.14	0.49
Llama	86.55	3.90	3.15	5.60	0.80

6.15

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3.00

Average Composition of the Milk of Certain Mammals

Water % Protein % Fat % Lactose % Ash %

7.60

45.80

13.60

22.42

54.00

19.40

4.80

4.70

2.40

2.50

none

?

5.30

1.15(?)

0.92

0.57

2.55

1.45

0.53

0.99

0.70

(From Modern Dairy Products, by Lincoln M. Lampert. Chemical Publishing Company, 1975) preneur will market one of the richest of all, porpoise milk, which is almost half fat (cow's milk is less than 4 percent fat on the average). Or it may become possible to get our protein needs filled with rabbit's milk, which has more than triple the protein content of cow's milk and ten times as much as human milk. True, it may be difficult to industrialize the milking of thousands of little cottontails, but on the other hand, there should be no problem in raising plenty of these milch rabbits in a short space of time.

The reverse is true with goats. They are easy to milk, and special goat-milking machines have already been manufactured. But goats, contrary to all the legends about goateared satyrs and rutting Pan, are not the world's most avid breeders. Wagner says that the most difficult part of goat dairying is to manage production properly. This, he says, may require a system of mutually visible breeding pens so that the sight of other animals in action will arouse a sluggish buck. Furthermore, since the doe's estrus is very brief, a matter of hours, it is conventional to leave a pair together for several weeks on the theory that "once" may not be enough.

Successful breeding, while important in itself, is also an essential prelude to milk production. Once a doe has "freshened," she will generally lactate for eight months. And during this time, she will give roughly two to four quarts a day of a milk whose unusual and sophisticated taste is the result of a special combination of chemical and physical characteristics.

Goat's milk looks and feels very much like whole cow's milk. It is white and it has the same proportions, roughly speaking, of water, fat, protein, lactose (milk sugar), and ash. But your taste buds will instantly tell you that no cow ever gave this tangy milk. It has the peculiar odor and taste you may already know from having tasted feta or some other goat cheese. There is an edge to it. You are, in fact, tasting three fatty acids with the goaty names caproic, caprylic, and capric. They are also present in cow's and mother's milk but in significantly lower amounts. To take the extreme case, capric acid is four times more plentiful in goat's milk than it is in cow's milk and roughly six times more concentrated than it is in human milk.



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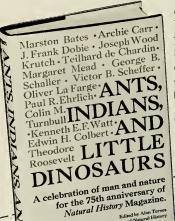
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To discover the second special trait of goat's milk, let a quart of it stand in the refrigerator for fortyeight hours. It should take about that long for a thin layer of cream (which, incidentally, can be whipped stiff just like cow's cream) to rise to the top. With a bottle of unhomogenized cow's milk, you should get a much thicker layer of cream overnight if not sooner. Unhomogenized cow's milk contains something like 1,500 billion fat globules per pint. They range in diameter from 1/10 micron to 20 microns. The globules have an outer coating, or membrane, composed, among other things, of protein. These membranes get broken up during the churning process and allow the fat inside to coalesce into butter. Normally, however, the membranes remain intact and they can, under the right circumstances of temperature and when a complex of other factors prevail, stick, or clump, together. Clumping facilitates the rise of the lighter-than-skim-milk globules to the top. The bigger globules clump and rise first and fastest. Homogenization essentially squeezes the big globules into smaller ones. Globules below a certain size tend to stay suspended uniformly throughout the fluid medium. They are also easier to digest.

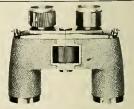
These principles clearly also apply to goat's milk. But the fat globules in goat's milk are all very small to begin with, so that goat's milk is naturally homogenized and easily digestible. Goat's milk fat globules are tinier even than the globules of homogenized cow's milk, and they have an additional digestive advantage. Their membrane is softer than the membrane of cow's milk globules. Dairymen say that most cow's milk is a hard-curd milk, while the milk of goats is a soft-curd milk. Put another way, the protein casein, which predominates in the membrane of the cow's milk globules, is tough, so much so that it is used to make buttons and glue. Goat casein is soft, useless for making hard plastics, but excellent for weak stomachs. This is why goat's milk has long been prescribed for infants with sensitive digestion. And it explains the normally softer, more crumbly texture of goat cheeses, which do not harden as cow's milk cheeses do when they are completely drained and have the whey pressed out of them.

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Technically speaking, the hardness or softness of milk curd is referred to as its curd tension. This can be measured by pulling a knife through curds that have been precipitated out of whole milk. The force, in grams, needed to pull the knife is the curd tension. For example, hard-curd cow's milk has a curd tension of 60 grams or more. Softcurd goat's milk has a curd tension of 30 to 40 grams.

Ordinarily, people precipitate curds to make cheese. (The first step in cheese making is, often, to churn, or separate out, the butterfat, leaving skim milk or buttermilk.) There are four basic methods for curdling milk: (1) with a centrifuge, (2) with an acid, such as lemon juice, (3) through bacterial souring, or (4) with a proteolytic enzyme, such as rennin (available commercially as rennet).

Purposeful curdling occurs at temperatures slightly above normal room temperature. Then, "concupiscent curds" solidify and separate from the anemic-looking, liquid whey. Now, if you should happen to have some goat buttermilk, you can easily prepare a simple cottage cheese at home. It will have much more personality than regular, store-bought cottage cheese, for as William Blake put it in another context, "the lust of the goat is the bounty of God."

Cottage Cheese

- 1. Heat any amount of goat buttermilk (or cow skim milk) over very low heat until it curdles and the whey rises to the top.
- Pour off as much whey as you can; then dump the curds onto a double thickness of cheesecloth. Tie it up, refrigerate, and let it drip for six hours or overnight. (A straw basket or colander, placed over a bowl, will work well.)
- 3. Place curds in a large bowl and cut them as fine as you can for cottage cheese. Or you may wish to press the curds through a sieve.
- Stir in salt to taste. Chill until ready to serve. Pour off any excess liquid that has separated from the cheese mass.

Raymond Sokolov is a free-lance food writer. His first novel, Native Intelligence, was published this spring.

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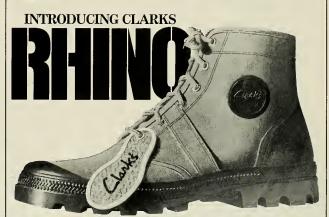
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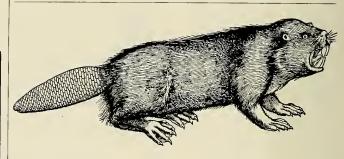


A Touch of the Poet

BIOGRAFFITI: A NATURAL SELECTION, by John M. Burns. Quadrangle/The New York Times Book Co., \$5.95; 128 pp., illus.

How does a biologist deal with the more weighty concerns of his disci-

pline? Sets them in rhyme, naturally. Subjects them to the outrageous pun; then smothers them in doggerel and humorous verse. What follows is a sampler from the pen of John M. Burns, a lepidopterist by profession—an Ogden Nash at heart.

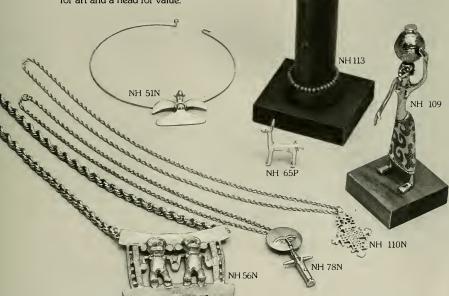


Beaver Damn

Let us
Dam
The stupid
Eager
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Knowing not
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From a
Pole in the
Ground
Persists in
Barking
Up
The wrong



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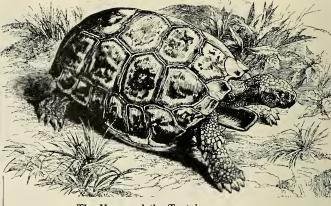


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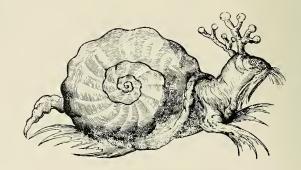


The Hare and the Tortoise

We as much as the insufferable hare Stared one to another in unuttered Disbelief at the tortoise's dare. Recovering his tongue, the hare served up His scorching brand of mock turtle fare As we prescribed a racing course That ended where it began, there At the trumpet vine.

They were off . . .

Our short wait lengthened through glare
To dusk when we strained to see the winner
Coming tortoise. Fair and square
He had plodded through the smug sleep
Of the hairy braggart who, in a scare,
Now tore to second place, shouting
S.O.B. (or some other macronym),
And slunk away muttering Snafu
(An acrimonious anachronistic acronym).



To a Lonely Hermaphrodite

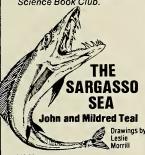
Know Thyself.

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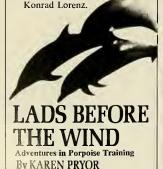
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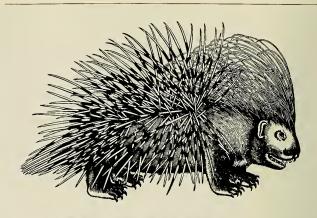
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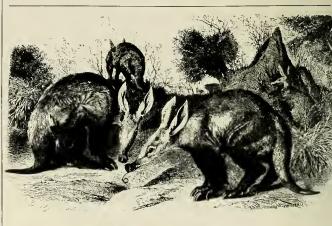
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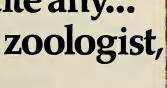
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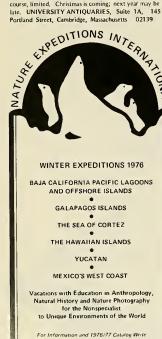
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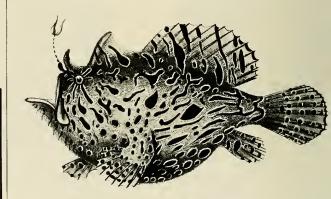
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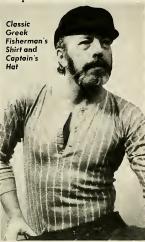
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Books in Review (Continued)

A RIVER FOR THE LIVING, by Jack Hope; photographs by Robert Perron. Barre/Crown Publishing Co., \$14.95; 224 pp., illus.

If one could stitch together all the words and pictures documenting the past, present, and future of the Hudson River, the aggregate would surely stretch from Lake Tear of the Clouds to the Battery, shore to shore, and then some. The mighty Hudson invites examination. It is, as Robert H. Boyle observed in his own fine contribution several years back, the river-the cornerstone watershed, a flowing litmus of all that is bad and beautiful in America today. So much of it has been documented so successfully in prose and photograph over recent years that reexaminers are now hard pressed for fresh material. The strain can show.

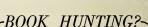
In A River for the Living, Jack Hope and Robert Perron strive bravely to eschew Hudsonian clichés. The obligatory visit to Lake Tear, high on the flank of Mount Marcy, is there at the beginning, but Hope's reflective account of their overnight hike to the headwaters is fresh and clear; and Perron's blackand-white photographs whisper of morning mists and October ice. For thirty-four pages or so, the fast pace and the style swept me into the book. I looked forward to the rest of the downriver run, knowing that Hope had wisely charted neither a crash course through the river's history nor a rehash of its ecological lore, but rather a sort of picaresque droppingin on the various human types whose lives are skewered by the stream itself.

Yet, alas, the flow of the book soon replicated that of the Hudson, becoming opaque and turgescent, with occasional clear and sparkling stretches between the outfalls of effluent. I am an admirer of Jack Hope's talents as a writer, and it pains me to find that he writes here so much with his ears instead of with his eyes and his heart. Dialogue runs through some chapters as if from a tape cassette, as if Hope was bent on chronicling the verbal banalities of some of his less-admired subjects-such as kayak jockeys, whose best measure of a white-water river is the stopwatch, or car-pool commuters from Rockland County, to whom the river is just a nuisance.

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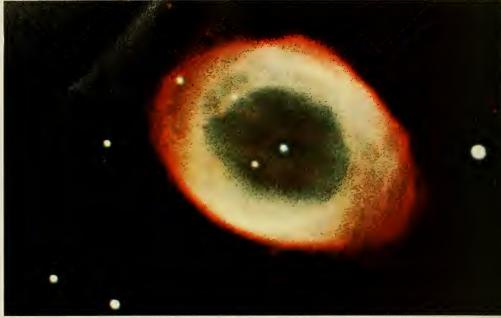
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In making these people unrelievedly dull, Hope unfortunately succeeds in making parts of the book dull as well.

Still, there are brighter interludes along the way, when, for example, Hope encounters people he obviously likes and respects: the shadfishing Nacks of Claverack, dispensing cut-rate fillets to their needier neighbors; the crewmen of a river tugboat; the teen-age girl from Beacon, a member of the Clearwater crew, who understands that the "land . . . owns itself"; or Frank and Arnold, the almost down-andouters who take striped bass and eels off the 96th Street sewer outfall and joke about Bella Abzug's hats.

The photographs are stark, and that is fine-or would have been with better reproduction. On more than a few plates in my copy, the ink looked as if might have been applied by heavy artillery. No fault of Bob Perron, who deserves better. Although I must say I come away from his downriver photographs with the distinct impression that the Hudson, with all its steel trusses, rotting piers, ghost towns, and garbage dumps, may still be just a little less for the living than we would like to admit.

JOHN G. MITCHELL

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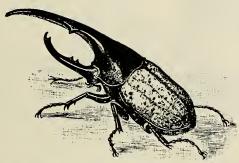
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Announcements



The sixth annual West Side Day will be celebrated on Saturday, October 4, from 10:00 A.M. to 4:45 P.M., at The American Museum of Natural History. An original puppet presentation, whose theme was inspired by the Maya legend of a mystical "jaguar-sorcerer" in quest of a sacred quetzal bird, will be given in the Hall of Mexico and Central America: dances from the Philippines can be seen in the Hall of Peoples of the Pacific; live entertainment, including a Caribbean music and dance festival. will be featured in the Auditorium throughout the day; traditional American Indian stories, illustrated with slides, will be told in the Hall of the Indians of the Eastern Woodlands; and the Education Hall will be the setting for a film festival.

Children may enjoy decorating precut felt elephants, converting clay into dinosaurs, investigating various Guatemalan textiles, watching a backstrap weaving demonstration, inventing sea creatures to be pasted on an "oceanscape," learning needlepoint techniques, or seeing a presentation interpreting the role of birds in legend, dance, music, and other art forms. Admission is free to all. For details and further information call 873-1300, ext. 566 or 559.

The Hayden Planetarium celebrates its fortieth anniversary in October. The event will be marked by special activities for the entire month, including an evening of astronomical poetry readings, a film series, and a benefit dance to be held on October 9, from 9:00 P.M. to 1:00 A.M. For detailed information contact Jeannette McElvenny at 873-1300, ext. 511 or 363.

Beginning October 18, the following Calder Workshops for Young People will be offered on Saturdays and Sundays: "An Introduction to Mammals' examines mammals' distinguishing characteristics, such as teeth and fur, and the keeping of a field catalog; "Sharks" studies shark behavior; "Fangs, Scales, Shells, and Skin" examines amphibians and reptiles, both living and prehistoric; "Introduction to Insects" involves collecting, studying, and identifying common local insects; "Exploring with the Microscope" teaches beginners how to make slides and do basic work with cells-advanced students will investigate bacteria, molds, and pond-water life; "Understanding Animal Behavior" includes field trips to Central Park; "A Close Look at the Museum" examines six of the Museum's Halls, including construction of exhibits; "Introduction to Photography"; and "Growing Cactus and Other Succulents." For complete information on dates, times, and fees call the Museum's Department of Education, 873-7507.

The Hayden Planetarium's Sky Show, "A Year Full of Stars," will run through December 1. This show explores the stars and constellations of the whole year as seen from all parts of the earth and examines the astronomical progress of the past forty years, including new techniques, such as radio astronomy and space satellites, which have enlarged our view of the universe. Sky shows begin at 2:00 P.M. and 3:00 P.M. during the week with more frequent showings on weekends. Admission is \$1.75 for adults; \$1.00 for children.

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In short, Moneysworth is a live wire sparking off hot information on the current money scene. It galva-nizes readers all over the country into sending ardent letters like these:

• "The government has proven itself completely impotent in the fight against inflation. My only salvation comes from advice I find in Moneysworth. It save me as much as I lose through inflation."-Theresa Ramseier: San Francisco.

"Your article on the 15% interest paid by Mexican banks has made est paid by Mexican banks has made it possible for me to retire in style."

-Eric T. Svenson; Fallbrook, Calif.

• "Thanks to Moneysworth, I am \$5,417 richer. I battled the So-

cial Security Administration unsuc-cessfully for 18 months, then finally won out by following the advice of your article 'By All Means, Appeal'."

-S. Dominguez; Waterbury, Conn.

"Your article on air-fare My wife and I saved \$100 each on a trip to New York by stopping off at Las Vegas as you suggested."-H. Kesselman; Los Angeles.

• Boys, you are not going to believe this, but I have parlayed \$146 into \$90,000 thanks to your informative article on breaking into real estate."-Horace T. Pinrose; Montgomery, Iowa.

• "Your write-up on income

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• "We salute Moneysworth for

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· "Your recommendation that readers reduce orthodontic bills by having the work done at a university dental school saved me \$1,350 on my daughter's teeth."-Bob Walters;

Oxon Hills, Md.

"Your tip on flying to Europe via Afghanistan saved me \$450. You've made me a subscriber for life."—Charles B. Fager, M.D.; Harrisburg, Pa.

Your advice on Social Security resulted in a \$3,135 lump-sum cash payment to my wife, and \$171 monthly pension. The best investment I ever made was a subscription to Moneysworth."—Dr. Herman W.

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"As a result of your article on nonprofit, low-cost memorial associations, we have been receiving 400 inquiries per day. You'll get an inkling of the immense amount of money your subscribers have saved when you realize that each of our members sayes well over \$1,000 on a

funeral."-R.J. Stevens, President, Continental Association of Funeral and Memorial Societies; Chicago.

"Your tip about deducting the

cost of transportation between my two teaching jobs saved me in taxes at least the cost of a ten-year sub-scription. Not only that, but your publication is lively, off-beat, a delight to read."—Professor Reuben Garner; State University College; Brockport, N.Y.

"Thanks to your article How

to Buy a New Car for \$125 Over Dealer's Cost,' I just bought a Chevy at a saving that I estimate at \$350."

Ron Bromert; Anita, Iowa.

"Your article 'Inaccurate Billing by the Phone Company' led me ing by the rhone Company learning to discover four years of over-charges. I got a \$1,593 refund."

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Irattic licket' saved me a \$ 2000 lawyer's fee and a licket."—W.R. Wendel; Hicksville, N.Y.

"Your article 'How to Avoid
Paying an Exorbitant Doctor Bill'
saved me \$65."—Carl Wagner; Yorktown Heights, N.Y.

"Your expose of charity rack-

ets was a shocker, I've crossed several well-known organizations off my list, saving hundreds of dollars." list, saving hundreds of dollars."
-Freida McMullin, Steilacoom. Wash.

• "Your article on how to save \$100 on a color TV worked. Mon-

\$100 on a color IV worked. Mon-eysworth sure knows how to hold onto the green."—P. Allen; Dir. Stu-dent Union; Henderson College; Arkadelphia, Ark.

"Your article on 'coupon re-funding' got my husband and me hooked on the hobby. It saves us enough each year to pay for our worker." Cross. Eller Eximand. vacation."-Grace Ellen Feingold: Brooklyn, N.Y.

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a times over, — C.B. Russel, N.T.C.

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The luxury of a Volvo 164 isn't something you just see. It's something you feel. A sense of elegance that's not gaudily apparent. But

very much real.

Inside, for example, there are no brocades or wood-grain veneers. Yet, in its own way, the interior of the 164 reeks of quality. You can smell the fine leather used to face the seats. And these seats are a luxury in themselves. Numerous automotive journals have pronounced them "among the most comfortable in the world.

On the dashboard, no fancy dials or gadgets. The only instrument you may be unfamiliar with is the tachometer. Which in the 164 bears watching. The three liter, fuelinjected engine is so smooth and quiet, the tachometer is sometimes the only way to tell if you're in second or fourth gear. (No extra charge for 4-speed manual

transmission.) Exposed structural parts of the Volvo body are made of rustproof galvanized steel.

Rustproofing isn't just sprayed on. It's drawn into the metal with a powerful magnetic charge before Volvo receives its final exterior coats. The result is an exterior finish that surpasses any mere "paint job." Even the striking metallic finishes are included in the base price of the Volvo 164.

Its overall styling, like all the world's truly elegant cars, is if anything over understated. It cannot be confused with those so-called luxury cars whose arrival loudly proclaims. 'dollars, dollars, dollars!

The Volvo 164 simply states. "sense."

VOLVO 164 The luxury car for people who think.





A remarkable new device is saving two kinds of energy-elbow grease and fuel oil.

Our photograph shows you a new invention in action—a scrubbing machine, named SCAMP™. It's solving an age-old problem for Exxon and other companies who operate large ocean-going ships.

Keeping any ship's hull free of barnacles and other marine growth has always been a headache for sailors. When the growth builds up, it slows a ship down. This wastes fuel. And fuel today is valuable energy.

The traditional way to get rid of marine growth is to haul your sailboat or ship out of the water and start scraping. But that's not so easy when your ship is a tanker that stretches the length of three football fields. Dry-docking this size ship costs you time and money.

Thanks to SCAMP equipment, that's no

longer necessary. An affiliate of Exxon developed it to clean the hulls of big ships—while the ships are at anchor, loading or unloading.

This new device is basically remote-controlled. As it travels underwater along the hull of a ship, its three rotating brushes whisk away marine growth. It's so fast it can clean the entire hull of a supertanker in just half a day.

In today's energy-tight world, SCAMP is performing a vital service. It is making the movement of crude oil around the world more efficient and more economical.

A clean hull can reduce the fuel consumption of a large tanker. For example, in a 10,000-mile voyage, a 1,100-foot tanker could save 60,000 gallons of fuel oil.

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A fact of life that naturally limits the number Aynsley can create. (Take note, collectors.) African Bull Elephant, 914"x834" h. Red Squirrel, 31/2"x41/8" h. Red Fox, 31/2"x11%" h. Baby Owl, 31/16"x4" h. Snowy Owl, 41/4"x71/4" h. Koala, 4%"x6%" h. Screech Owl, 4"x7%" h. Polar Bear, 64"x5%" h. Raccoon, 7%"x5" h. Baby Bull Elephant, 6¼''x3½'' h. Fawn, 5¾''x3¾'' h.

Prices range from \$75 for the Baby Owl to \$300 for the African Bull Elephant. Aynsley China, a member of the Waterford Family, 225 Fifth Avenue, New York 10010.

Take the whole jungle for \$1545.







The Mercedes-Benz 450SE. Engineered like no other car in the world.

The Mercedes-Benz 450SE is a pure combination of advanced automotive technology, enlightened engineering, safety and craftsmanship.

And though a host of "brandnew" automobiles have been introduced in the past several months, the world has never seen a production sedan like it.

n the *outside*, the 450SE Sedan is not as big as a full-sized American luxury automobile. The only thing big about this Mercedes-Benz sedan is the room *inside*. The 450SE is a five-passenger sedan with more than seventeen cubic feet of trunk space.

Many engineers agree that this is the shape and size of the automobile of the future. For some domestic manufacturers, the future has to wait until at least 1978. For Mercedes-Benz it's here now.

Aircraft construction

The Mercedes-Benz 450SE has no separate body or chassis structure. Its panels are fused into a unit with over 6,000 individual electric welds. This basic method of construction allows modern jet aircraft to have enormous strength and light weight.

The awards winner

The 1975 Motor Trend Magazine Golden Wheels Awards have just been announced.



Outstanding Achievement in Engineering

Winner: The 450SE.

Areas evaluated: The ride/
handling relationship; performance, e.g. expressway
entry, passing, hill climbing and stopping; passenger capacity and comfort;
ease of entry and exit and
accommodations; total engineering concept and quality of execution.

Outstanding Achievement in Safety Winner: The 450SE.

<u>Areas evaluated:</u> Avoidance capability; braking response; visibility; innovation; occupant protection.

Safety first

The structure of the 450SE is the latest of Mercedes-Benz developments of the patented rigid passenger cell/deformable extremity construction. Both the front and rear extremities absorb force in the event of an impact, to help the passenger cell remain intact.

The 450SE's gas tank is mounted over the rear suspension, well in from the rear bumper, and sur-

rounded by steel bulkheads. What's more, the gasoline filler neck has been designed to pinch itself closed in the event of impact.

Unlike all domestic sedans which continue to have the same basic wagon-type rear axle they have had for decades, the suspension of a 450SE is fully independent. This system is completely different and allows the standard steelbelted radial tires to stay mated to the road where they belong.

Mercedes-Benz goes to great expense and effort to initiate new suspension developments. They can spell the difference between accident and incident.

Lasting value

One final thought. Today, when more than ever before, everyone is searching for lasting value, a Mercedes-Benz 450SE has much to offer you. Mercedes-Benz has the best resale value of any make of car sold in America. Any one. And the 450SE is pure Mercedes-Benz.

A unique driving experience awaits you at your Mercedes-Benz Dealer's. Call him today. Test drive the 450SE.

NATURAL HISTOR

Incorporating Nature Magazine Vol. LXXXIV, No. 9 November 1975

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Cover: A strong attachment between mother and infant is typical of chimpanzees. Elaborate maternal care among primates is part of a reproductive strategy involving few offspring and the efficient uses of food sources. Photograph by H. Albrecht, Bruce Coleman, Inc. Story on page 48.



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Authors

Believing that eradication of disase is an inextricable part of national levelopment, Gerald T. Keusch has levoted his career to the study of inectious diseases in the context of poverty and malnutrition. This interst has taken him to Thailand and to Guatemala, where he worked with he Institute of Nutrition of Central America and Panama, In addition, he as conducted basic research, in his aboratory at Mount Sinai Hospital in New York City, on the effects of malnutrition on immune functioning. A nedical doctor, Keusch is associate rofessor in the hospital's Division of nfectious Diseases.



After a recent sojourn as visiting professor of physical anthropology at Yale University, R.D. Martin has esumed his supervision of the deailed studies of mammalian reproduction being conducted at the Wellcome Institute of Comparative Physiology. The institute, of which Martin s a senior research fellow, is a branch of The Zoological Society of London.

His present work on primates has led to a planned expedition to Madagascar later this year to investigate the behavior and ecology of bush babics. He is also contemplating a study of the relationship between body size and evolution in primates. Martin previously wrote "Ascent of the Primates." for the March, 1975, issue of *Natural History*.



Having spent many years observing the behavior of insects in her backyard, E. Jaediker Norsgaard vonders why "suburbanites destroy latural settings by mowing everying down," which not only reduces nsect populations but also limits the pleasure to be gained from watching



them interact. Norsgaard, a commercial artist for many years, is the author of several magazine articles and children's books on insect communities. She has also written narrations for nature films, which her husband, Campbell Norsgaard, filmed and produced for distribution in schools.



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Born in New Zealand and educated there and in California, Noel D. Vietmeyer now lives in Virginia and works in Washington, D.C. An associate in the Office of the Foreign Secretary at the National Academy of Sciences, he specializes in the utilization of aquatic weeds and the applications of science in developing countries. Fascinated by such offbeat and neglected areas of knowledge as obscure tropical animals, Vietmeyer is devoting research time to the preservation of manatees and dugongs. He holds a Ph.D. in organic chemistry from the University of California at Berkelev.

"Alfred Moon's Farm" is based in large part on the recollections of 85year-old dairy farmer Arthur E. Rosenburg, who was interviewed at length by coauthors Richard F. Olivo (left) and Henry W. Art (right). In 1911, Rosenburg went to work on a nearby farm in Williamstown, Massachusetts, where he first met Moon. Because of his long experience, keen observation, and excellent memory, Rosenburg has a fund of knowledge on the details of New England farm life in the early twentieth century.

Richard Olivo is an assistant professor in the biological sciences at Smith College and an active filmmaker. Henry Art is an assistant professor of biology at Williams College and assistant director for research at the college's Center for Environmental Studies.





David Andersen has a degree in medieval literature, a taste for folklore, and a sensitivity to Finnish traditions (his father is half-Finnish). These attributes led him to accept an appointment in 1973 as Fulbright lecturer in American literature and folklore at the University of Helsinki. While there he looked into Finland's own rich folklore, including accounts of the origin of gypsies and beliefs about conception and birth. Devastating weather shifts encountered during ski trips along the Gulf of Finland caused him to investigate traditional Finnish weather prediction. Andersen is associate professor of English at California State College at Northridge.

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Letters





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More Ado About Starlings

John W. Miller's article, "Much Ado About Starlings" [August-September, 1975], was not only needed but also points out a need for research on control methods. Too many people still think starlings are innocuous organisms. Since starlings have no natural enemies in the United States, perhaps we should apply the same principle that has controlled and exterminated other species—find a recipe and declare open season on them. The hunters will do the rest.

Leonard J. Garigliano Salisbury State College Salisbury, Maryland

A few years ago I was astonished to see a bird apparently pecking at the eyes of a Hereford cow. The bird remained on the ground, hopping up at the eye as the cow grazed, seemingly unconcerned. I became convinced the bird was a starling and its diet, face flies. More recently I have watched starlings walking about on the faces of cattle, perching on horns, and feeding on face flies so determinedly and for so long that I have left them to their dining and resumed my chores. This morning, seeing a starling riding against the horizon on a Hereford, and noting your recent starling article, I felt I should call your attention to another of their adaptations.

DAVID K. TATE Coopersburg, Pennsylvania

Man and Chimp

The article, "Man and Other Animals" [August-September, 1975], by columnist Stephen Jay Gould effectively pleads the case for the low genetic distance and insignificance of the qualitative differences between

humans and chimpanzees. Experimentation with the timing and regulation of developmental events as controlled by regulatory DNA sequences certainly is the research frontier in studies of higher primate evolution.

Gould is incorrect, however, in his cytogenetic explanation of why a human-chimp hybridization attempt would fail to produce an offspring. He is correct in saying that chromosomal rearrangements are present between chimp and man despite qualitatively similar DNA (low genetic distance). However, the presence of chromosomal rearrangements between parents is not the reason for the lack of a hybrid, but it can be a reason for the reproductive sterility of a hybrid. Chromosomes do not pair in the mitotic cell divisions, which produce an adult from a zygote. Chromosomes pair in the meiotic divisions. which precede sexual reproduction; and a failure of pairing, due to chromosomal rearrangements, usually results in reproductive sterility.

Among animals in natural situations, many diverse barriers have evolved which prevent interspecific hybridizations, not the least of which is behavior. Because of the low genetic distance between us and the chimpanzees, an evolved behavioral reproductive barrier may be all that prevents the production of a hybrid. If this indeed be so, we need not be apologetic about it. We should accept the "continuity between ourselves and nature" and realize that behavioral barriers to the flow of genes between two animals adapted to different environments are as effective and as natural as any barriers.

> DWIGHT T. KINCAID Wake Forest University Winston-Salem, North Carolina

In the column about my great, great grandfather, the chimpanzee,

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Stephen Jay Gould not only writes an erudite scientific article but also branches out into theology. He does a lot better than Saint Augustine. He just about sums up all theology in a few words, to wit, "The only honest alternative is to admit the strict continuity in kind between ourselves and chimpanzees, and what do we lose thereby? Only an antiquated concept of soul. . . . " If Stephen Jay had only written that article a few years ago he would have saved me a lot of trouble. I've spent some thirty-eight years as a missioner on two continents, at times under trying circumstances. Even amongst "pagans" I didn't learn that the concept of our soul was antiquated-but if I had only known, what a lot of tears and travail I could have avoided!

But who am I? Think of Michelangelo. How many years was it he spent on his back drawing The Last Judgment on the ceiling of the Sistine Chapel? And now this is all canceled out. But at least a good story has come down to us about this painting. An eager beaver cardinal kept breathing down Michelangelo's neck to see the incomplete picture. When Michelangelo painted hell he put the cardinal right there, robes and all. The cardinal remonstrated with the pope who answered, "Now if he had painted you in purgatory I could do something about that, but once you are in hell. . . . ''

Then there was that genius Leonardo da Vinci, whose Pietà portrayed the death of God in his mother's arms. Perhaps he could have chiseled out one of our ancestors.

If only God had known there was no soul, he wouldn't have had to empty his Divinity (Saint Paul), assume human form, and preach his gospel to a soulless world.

The four Gospels really present another problem. This book has had the largest printing of any book in existence, and in just about every language on the face of the globe, but it was written on the assumption of the existence of a soul.

As I approached the end of Gould's article, it seemed to me that he had found the real difference between the chimp and me, we can't "hybridize." To me that means we can't talk together or laugh or fall in love or get married, for one of us has a soul and one of us hasn't.

REV. JAMES H. RAY Sherman, Connecticut

Address_

Smallpox Gamble

In his article, "The Dubious Gamble Against Smallpox" [August-September, 1975], Pascal James Imperato expresses an appropriate respect for the potential of smallpox virus to thwart the World Health Organization's smallpox eradication program.

Although theoretically possible, neither reintroduction from a possible animal reservoir, from variolation scabs, nor from healthy carriers has proved to be a practical problem. A recent, unpublished WHO study of material preserved by traditional variolators in Pakistan, Afghanistan, and Ethiopia concluded that "these data . . . suggest that variolation poses no serious threat to eradication." The variolators themselves reported that their material loses potency in three to twelve months. A group of investigators convened by WHO in December, 1973, reached a similar conclusion with respect to the

monkeypox question.

Smallpox's reappearance in smallpox-free countries has been clearly traced to known foci, which are shrinking daily. In a few documented instances, foci of low levels of transmission have been discovered in remote areas after remaining undetected for several months. Such hidden foci have been rare and will eventually be discovered or die out naturally. Persistence of the disease beyond the two-year minimum period of no confirmed cases, before an area is declared smallpox-free, would require at least thirty-five generations of undetected smallpox transmission. That the disease may persist due to virus that has been preserved for scientific study (or for other uses) is a possibility and a danger. In March, 1973, an accident in a well-known research facility in London resulted in four cases of smallpox. I feel an international agreement should be drawn up to restrict or eliminate such sources of smallpox virus once the disease has been eradicated.

A few decades of experience with smallpox eradication is not long when compared to smallpox's probable 3,-000-year existence, but the odds are now overwhelmingly against the continuation of this disease.

DONALD R. HOPKINS, M.D. Harvard University School of Public Health Boston, Massachusetts



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The Bleeds

Humans as well as cattle have benefited from identification of the cause of this disease

In the first quarter of this century, there were numerous reports of cattle fed on sweet clover hay dying of massive hemorrhages with blood spurting from their noses. New-mown grass seems innocent enough. Its distinctive scent (known to everyone who has mowed a lawn) comes from a compound called coumarin. In pure form, coumarin is mildly toxic, causing liver disorders and some kidney changes in livestock. But relatively high amounts are needed to cause any pathology, and animals cannot possibly eat enough plant material containing the substance to bring about even mild symptoms. Nevertheless, cattle fed on clover silage often died within a few days, as noted in 1919 in the Canadian Veterinarian Record by F.W. Schofield. He described in detail the clinical symptoms of the disease, commonly called "the bleeds," and cogently reported that in all cases ending in death, the cattle had fed on moldy hay.

Schofield then ran an elegant ex-

periment. He carefully separated stalks of clover hay into two piles-in one, the plant stems were visibly clean of mold; the second was composed of perceptibly moldy plants. Three laboratory-raised rabbits were fed clean hay and three were fed moldy hay. Those that ate the infected clover developed typical sweet clover disease symptoms and died within days.

Schofield then took the next big experimental step. He isolated several fungi from moldy clover and used them to infect clean plants. The artificially contaminated hay turned rab-



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caused a dramatic drop in the ability of their blood to clot, and death from massive hemorrhaging followed. During the late 1920s many investigators attempted to isolate the toxic substance in the moldy hay. They iniected coumarin in solution into experimental animals but the only posi-

tive results demonstrated that coumarin found in unmoldy have could

not be the poison and that some fraction of moldy hay increased the blood-clotting time of sick animals.

bits into bloody corpses. Extracts of

moldy hay injected into the rabbits

Serendipity now enters the story. In February 1933, a Wisconsin dairy farmer, who had lost two heifers from the bleeds and had a cow die after a slight scratch from a barbed wire fence, noticed that his prize bull was bleeding from the nose. Loading his truck with the dead cow, a hundred pounds of sweet clover hay, and several milk cans filled with the blood of a heifer that had died the day before, he drove the 200-odd miles to Madison in a raging Midwest blizzard, hoping to find the state veterinarian at the University of Wisconsin's College of Agriculture. But the veterinarian was out of town, so the farmer went into the agricultural biochemistry building to ask where he could leave his gruesome load. There, by chance, he met Prof. Karl Paul Link, who was familiar with sweet clover bleed disease. Link urged the farmer to stop feeding his cattle moldy hay but could not hold out any hope for his already sick animals. After the farmer left, Link opened

one of the milk cans out of idle curiosity and saw that the blood was still liquid. Even in that cold weather, normal blood would have clotted. Obviously this unexpected behavior was what the bleeds was all about; any simple injury, even a scratch from barbed wire, would rupture at least a capillary and with the failure of normal clotting, internal bleeding would cause death. This, of course, is the fear of the hemophiliac.

Link decided to become involved in identifying the substance causing the bleeds. To this day, he does not know why. He just decided. At the same time, he made another decision that gave him a commanding lead over other scientists who had worked on the problem. All the earlier workers injected rabbits with various compounds and then waited to see if typical symptoms of the bleeds developed. With little evidence, Link dentroductory offer

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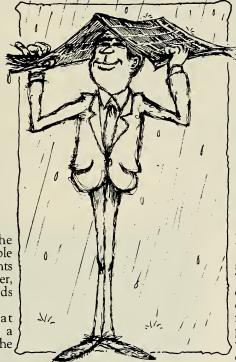
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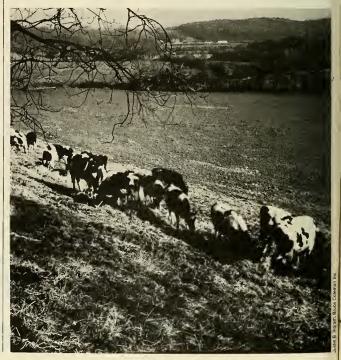
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cided that the clover bleed toxin must work directly on the blood and that an assay, or chemical analysis, could be developed that measured bloodclotting time, a much simpler and more direct assay system than using whole animals. The trouble was that the only commonly used method of measuring blood clotting in the 1930s was crude and somewhat unreliable. Link first had to improve and standardize the clotting assay. Once that was out of the way, he could turn to the biochemical isolation of the toxic substance that caused the bleeds.

Literally tons of moldy sweet clover hay were chopped up and extracted with alcohols, ethers, esters, and other possible solvents. By 1938, a concentrate with more than 200 times the anticoagulating activity of moldy hay had been obtained, and ether extracts were further concentrated until in 1939—a full five years after the project had started—a member of Link's research team obtained four or five tiny crystals of the active ingredient on a microscope slide. The compound not only prevented blood clotting but a dilute solution also produced the typical bleeding symptoms in rabbits. By 1940, 1,800 milligrams (about ¹/₁₄ ounce) had been isolated

and the chemical structure of the compound had been determined. Two years later the substance was synthesized. Named dicoumarol, the compound is essentially two modified coumarins linked together through the action of several common fungi.

Although this finding was a neat job of laboratory research, it did not seem to be of much use to dairy farmers. What did prove to be important was the research thinking that followed. Using their own work, and that of other laboratories, Link's Wisconsin group started putting together the information on dicoumarol and that on blood clotting. Skipping many details of the process, blood begins to clot because of the formation of a spongelike material, called fibrin, which traps the blood cells and seals off a wound. For fibrin to form, many chemicals interact, one of which is vitamin K. In fact, it was known at the time that individuals with the rarely seen vitamin K deficiency usually were bleeders. Dicoumarol prevents vitamin K from acting, thus fibrin does not form, and an injured animal that has ingested dicoumarol may bleed to death. The cure was obvious: animals showing the first symptoms of the clover bleeds could











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be saved by a massive injection of vitamin K. The dairy farmer's midblizzard trip was worth it.

The publication of these studies in the late thirties and early forties caused some medical researchers to perk up their ears. The availability of a pure compound that could prevent blood clotting was of great interest, for in a number of human diseases and in injuries as simple as a broken leg, blood clots can form, move through the body to the heart or lungs, and cause potentially fatal blockage of the blood flow. If an anticlotting agent could be administered, many deaths could be prevented. Heart specialists at the Mayo Clinic in Rochester, Minnesota, and at Cornell University Medical College in New York City, found that dicoumarol was just what they needed; with it, coronary thrombosis, caused by massive clots, could be controlled. Former President Eisenhower was one of thousands of people who, following a coronary episode, spend the rest of their lives on dicoumarol; and the blood clotting in phlebitis, as ex-President Nixon knows, is also much reduced by use of the compound, If, by chance, too much dicoumarol is taken, its effects can easily be counteracted with vitamin K.

End of the story? Not quite. In 1945, Professor Link contracted tuberculosis. To keep his mind occupied while recuperating, he decided to read up on natural history and the role of animals as vectors in human disease. His reading, which included Rats, Lice and History by Hans Zinsser, got him interested in those particular rodents. From his own laboratory work, he knew that rats are impervious to dicoumarol because they normally have high levels of vitamin K-about as high as that of a healthy human. What would happen, he wondered, if the dicoumarol was chemically modified? Could it then be used as a rat poison?

One reason for Link's train of thought was a curious thing he had read about rats. Rat packs, he learned, choose some wise old member as official taster. The pack will not touch a new food until the taster has eaten it and survived for several days. Since dicoumarol takes several days to work, this bit of rat lore led Link, after his recovery, straight back to the laboratory bench. The dicoumarol molecule was modified and Link and his coworkers tested the modifications on themselves, as well as on

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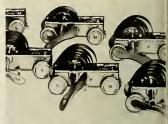
rats, guinea pigs, and chickens. Eventually they found that their "compound 42" met all the requirements for an effective rat poison. It killed rats by acute lung hemorrhaging without causing harm to humans and other animals. Called warfarin, compound 42 is an ingredient in most of today's rodent control compounds.

Is this the end of the story? No, not yet. Actually, the coumarins have played a therapeutic role for centuries. In India, for example, where skin pigmentation can be relatively dark, there has long been a disease, now called leukoderma-meaning white skin-which results in an unsightly, piebald appearance. The disease, also called vitiligo, occurs in about one percent of the United States population. Although the ancient Indians did not know the cause of the disease (nor do we), parts of their sacred literature, the Atharvaveda of 1400 B.C., recommended that certain herbs be mashed into a paste and applied to the whitened skin. And the Buddhists of A.D. 200 noted that after application of the herbs, the patient should stand in the sun. In every instance, the treated areas darkened within a few days and the process did not have to be repeated for several months.

In the first decades of the twentieth century many European doctors noted that some of their sunburn patients displayed the reverse of vitiligo, a darkening of skin areas-particularly elbows and knees-that were exposed to both sunlight and plants or plant products such as eau de cologne. Since these photodermatoses, or abnormal skin conditions, occurred only when the application of plant extracts to the skin was followed by exposure to sunlight, and since the reactions did not occur when the light was filtered through window glass, the radiation causing the skin darkening had to be shortwave ultraviolet light. (Window glass screens out short ultraviolet radiation.)

The similarity between these reports and the ancient Indian treatment for vitiligo was noted in 1940 by a dermatologist in Boston who happened to be Indian. He found that the active ingredient in the plants and curative herbs was a chemical derivative of coumarin that, when activated by shortwave ultraviolet radiation, caused changes in the pigmentproducing layers of the skin. By the late 1950s, a standard medication containing the coumarin derivative

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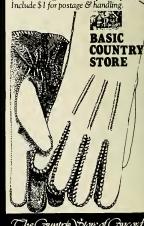
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had been developed for the treatment of vitiligo. More recently, cosmetic manufacturers, recognizing that this substance would produce a quick suntan, have tried it in some of their

preparations.

Coumarin itself was isolated and chemically characterized as long ago as 1820. Because of its agreeable odor, it has been widely used in the perfume industry. It is a major ingredient in perfumes with names like Breath of Spring, and in men's colognes called such things as Forests and Fields. Bergamot oil, another coumarin derivative, is used to "fix" perfumes, that is, to prevent the breakdown of the essential oils that give perfumes their odor. It has also been used to flavor chocolate and was formerly included in imitation vanilla extract and added to pipe tobacco to provide an outdoorsy odor. But bergamot has now been eliminated from many products because of the danger that they might become moldy and produce dicoumarol.

End of the story now? Well, almost. There is an exceptionally annoying disease, called psoriasis, in which red, scaly patches appear on the scalp, elbows, knees, and back. The name is derived from the Greek word for itching. Up to eight million Americans have psoriasis, and the ailment can drive the sufferer to distraction. The treatment has not been too effective and is also potentially dangerous because it can cause severe rashes and injure the subepidermal skin layers and the blood vessels beneath the skin. The researchers who worked up the remedy for vitiligo reported in 1974 that the oral uptake of yet another coumarin derivative, when combined with intensive exposure to ultraviolet irradiation, is a highly effective therapy for psoriasis. The research group also recently reported that various fungal diseases of the skin are responsive to the same treatment.

One final postscript. If you do any Indian, Mexican, or Chinese cooking, you use coumarin. The major flavoring ingredient in cumin seeds and in coriander (also called Chinese parsley and cilantro) is coumarin or a derivative. And so is the flavoring of the common parsley that we sprinkle on everything from boiled potatoes to our tongues—to kill the odor of onions.

Richard M. Klein teaches botany at the University of Vermont.

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Malnutrition and Infection: Deadly Allies

By watching the response of two children to the same common illness, a physician begins to understand the impact of poverty

I noticed the first red spot on my daughter's face just after we had cleared the health and customs inspections at the airport in Mérida, Mexico. While we were waiting for our luggage, the first lesion was joined by several others, and soon three-year-old Lyssa-feeling sick and feverish-was spotted like a leopard. That evening at dinner she was apathetic and fidgety and had no appetite. The rash had changed its character, and now I could see small, glistening fluid-filled blisters sitting in the center of each red spot, the classical "dew drop on a rose petal" rash of chickenpox.

In the morning, the original spots were crusting, but since new ones were appearing, we stayed in Mérida for the day. Lyssa rode around town in a horse-drawn cab and enjoyed the swings in an empty playground. On the third day of her illness, Lyssa's temperature was only slightly elevated and there were fewer new spots. We decided to visit the Maya antiquities in the Yucatan as planned. For the next three days we hiked, climbed the ruins of ancient temples, and rode a Land Rover to the more remote ruins in the Puuc hills. Lyssa, with her crusting rash, looked the worse for wear, but she hiked and climbed, enjoyed and fussed, like any three-year-old without chickenpox.

At the same time, Maria, a threeyear-old Maya living in the highlands

of Guatemala, stopped eating, developed fever, and began to have diarrhea. By the time the rash of chickenpox broke out, she had been ill for more than two days and was losing weight. When signs of pneumonia appeared the following day, Maria's alarmed parents decided to bring her to the regional hospital. After walking six miles, they reached the highway where they could hail a bus. And so, five hours after leaving home in the arms of her father, Maria was in the hospital being treated for severe chickenpox and malnutrition. She remained critically ill and continued to lose weight for the first ten days of her hospitalization. Then, somewhat miraculously, she improved: the fever and diarrhea finally subsided and she showed a slight weight gain. Still, when she was discharged after three weeks in the hospital, Maria had not regained her preillness weight or general state of health.

At this point my family and 1 arrived in Guatemala, where 1 was to study at the Institute of Nutrition of Central America and Panama (INCAP). And while Lyssa enrolled in a nursery school, Maria entered a nutritional rehabilitation center.

What was the difference between the response of these two children to the same common childhood illness? Was it simply a matter of luck, a difference in the virulence of the two virus strains involved, or perhaps a genetically determined resistance factor? What was to become consummately clear to me during that summer of study was the incredible toll in morbidity and mortality due to malnutrition and infectious diseases, which often operated together in a spiral course that led to permanent

physical and psychomotor retardation, if not early death.

In developing countries, the heartrending sight of pediatric wards filled with children suffering from complications of infectious diseases, principally because they are malnourished when stricken, usually leads to a simplistic, well-intentioned, charitable effort to provide food for these youngsters. Interventions, however, are neither simple to devise nor simple to implement. The problem is rooted in the social, cultural, political, and economic morass of national development policies and in the international relationships of nations. And beyond that, efforts to preserve and improve the health of children in developing nations (often burdened with incredible population growth rates, even in the face of excessive infantile and childhood mortality) are, on the surface, counterproductive because they increase the number of survivors competing for the same limited food sources.

Malnutrition is a problem of human ecology that can only be understood through careful examination of each of the factors that interact in the complex. Infection is one such factor, with a multiplicity of cause and effect repercussions. My purpose in exposing this spectrum of interlaced contacts-both direct and circuitous, overt and covert-between malnutrition and communicable diseases is that we may better comprehend the priorities of national planning and development for programs of action. Based on a basic premise I hold both as a physician and a medical scientist—that an understanding of the mechanisims of disease is the essential beginning of its eradication



Maya families live in small adobe huts with central cooking fires. The smoke is not only irritating, causing numerous cases of conjunctivitis, but can also damage respiratory cells.

leave the pediatric ward and enter the community.

The ravages of malnutrition are

These child tions so of the problem, rather than extant injustices. Such a premise does not beg the moral question since the results of this approach can be as striking and revolutionary as revolution itself—and often less destructive.

Infection is the end result of an intimate joining of the paths of two biological entities, the host and the result of an integrated converging under specific and the second of the paths of two biological entities, the host and the results of the second of the paths of two biological entities, the host and the results of the paths of two biological entities, the host and the results of the paths of two biological entities, the host and the results of the paths of two biological entities, the host and the results of the paths of two biological entities, the host and the results of the paths of two biological entities, the host and the results of the paths of

Infection is the end result of an intimate joining of the paths of two biological entities, the host and the agent, occurring under specific environmental conditions. These same three factors—host, agent, and environment—are the classic elements of the science of epidemiology, or the impact of diseases in populations. To understand what happens to an individual or to a population of individuals, we must first understand the environment in which we live—we must examine the ecosystem in its natural state. To do this, we must

most profound on the young and thus, most poignant. In some areas mortality rates are so high that half the live born die before their seventh birthday, their deaths usually caused by, or associated with, an infection, These children are sick with infections so often that it may seem that they are more or less continuously infected. In Santa Maria Cauque, Guatemala, for example, forty-five newborns were studied for their first three years of life. During that short period, they experienced nearly 2,500 episodes of a variety of infectious diseases. Diarrheal diseases accounted for more than two-fifths of the illnesses, with a peak incidence during the second year of life. Although we tend to think of newborns and young infants as particularly vulnerable, the experience in nearly every developing country demonstrates that the situation actually worsens for children one to four years old. The age at which this vulnerability becomes apparent usually corresponds to the age of weaning; with decreased intake of breast milk and no compensatory increase in other foods, the weanling becomes particularly susceptible to gastrointestinal illnesses, a syndrome known as "weanling diarrhea."

The interaction of malnutrition and infection can be succinctly stated: each makes the manifestations of the other worse. Regardless of the starting point, the two factors contribute to a never-ending cycle of infection to malnutrition to infection. What are the contributing mechanisms to this cycle? Broadly, these can be divided into the effects of infection on nutrition, the effects of malnutrition on infection (for example, effects on the manifestations of illness, as well as on defense mechanisms of the body against infectious agents), and occupying a middle ground, the effects of cultural responses to these main factors. Cultural practices can either mitigate or worsen these effects.

How does infection affect nutritional status? Perhaps the most readily documented and directly visible event during febrile infections is a generalized wasting of body tissues. People obviously lose weight during acute infectious illnesses, for the body literally begins to consume itself as muscle protein is degraded to its constituent amino acids. These, in turn, are released into the blood-

stream and redistributed from there to other organs, such as the liver. A degradative process, such as breakdown of muscle mass, is called catabolism, and during infection, catabolic processes seem to be triggered by fever. As the protein is being broken down, it is also being wasted in body secretions, to be permanently lost via urine, feces, and sweat (a frequent consequence of fever). All humans, regardless of their state of nutrition, lose protein nitrogen during an infection, but some can afford it less, and some cannot ever replenish the loss. The infected individual is a two-time loser, for in addition to the excessive loss of protein nitrogen, he is also taking in fewer essential nutrients. As we have all experienced, loss of appetite often accompanies infections. Whereas a healthy, uninfected individual can reduce urinary nitrogen loss to compensate for diminished intake, this reactive mechanism does not operate during the fever phase of an infectious disease.

If the infected individual is a small child with marginal nutritional status at the outset, he may become a three-time loser, for acute manifestations of protein-calorie malnutrition frequently develop in this setting. This is the disease of the bloated, apathetic child we have all seen in photographs of regions afflicted by famine, drought, or war. And the condition frequently terminates in death.

At the same time that the body's stores of nitrogen are being wasted, other constituents of the fluid interior compartment of cells—potassium, magnesium, phosphorus, zinc, and sulfur—are also being lost. No doubt, the loss of these minerals has important consequences, but we do not yet understand their full physiological significance.

Occurring simultaneously with these breakdown phenomena are what are called anabolic processes: the manufacture of body constituents, such as cells, tissues, and proteins. Many of these anabolic processes are part of the mobilization of the body's defenses to fight the infection, and are, of course, beneficial. Increased production of scavenger white blood cells, for example, which confront, ingest, kill, and digest invading bacteria, is crucial if the infected individual is to survive. Nevertheless, such production is in competition with the body's maintenance and growth requirements for the limited stores of protein and energy. When tissue

damage has also occurred, the need to repair the normal architecture means using protein and energy to repeat a task already accomplished once before.

In addition to white blood cells, the body synthesizes antibodies and other proteins. Among these are the antiviral substance interferon and a vital group of serum proteins that make up the complement system, whose function it is to augment and amplify the body's normal defensive response. There is no doubt that these proteins are necessary, for without them, severe and recurrent infections would occur. But when nutritional status is marginal, any need for the body to turn protein synthesis to production of these proteins represents a diversion from the growth or maintenance of normal tissues and organs.

This "rob from Peter to pay Paul" principle can be seen in the altered growth curves of children who, suffering some degree of protein-calorie malnutrition, also become infected. Weight loss and delayed resumption of growth, often resulting in permanent stunting, typically are part of acute febrile infections. And what can be seen and measured in physical growth stunting appears to mirror similar effects on brain and neurological growth, with permanent retardation of psychomotor development.

However disastrous the consequences, these anabolic processes do have a discernible purpose-augmentation of the body's defense mechanisms. But a variety of other anabolic events occur that do not have an obvious purpose, at least as far as is now known. Among these processes are increased synthesis of certain liver enzymes and of a group of proteins known collectively as acute phase reactants. In a malnourished individual, synthesis of acute phase reactant proteins represents a diversion of amino acids from other building processes and body functions.

This is not the body's only apparently unwise decision. In addition to diversion, two other types of "functional wastage of nutrients" occur. One of the most characteristic responses to infection, in fact, one of the cardinal manifestations of disease, is fever. From the physiological point of view, the purpose of elevated temperature in restoring the wellbeing of the body's ecosystem has never been clear. True, in isolated instances raised temperature alone can eradicate an offending microorgan-



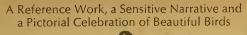
The effects of poor nutrition and recurrent infection are evident in this undersized eight-year-old girl. She has probably also suffered stunting in brain and neurological development.

ism, such as the bacteria responsible for gonorrhea or syphilis. In fact, in the days when there were no antibiotics, physicians would transmit malaria to patients with venereal disease, in the hope that the periodic rigors and fevers of malaria would cure them. (This strategy of fighting fire with fire led someone to muse that the wages of sin is the cure in hell.)

But in most instances fever does not seem to serve a discernible purpose. Therefore, the energy utilized to generate the heat, the depletion of carbohydrate stores from the liver, the utilization of amino acids from muscle to make new sugar in the liver, and the mobilization of stored fat all represent functional wastage.

Finally, during febrile diseases iron, zinc, and several trace metals are taken up by cells of the liver and

30





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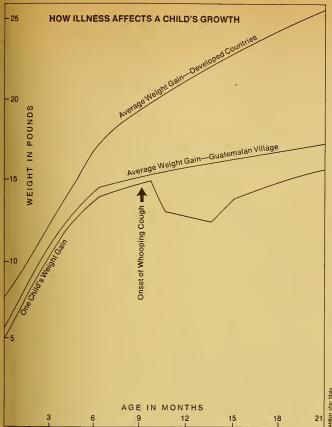
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locked, as it were, into a strongbox. This sequestration of iron removes it from the bone marrow, where iron is used to synthesize hemoglobin, the oxygen-carrying protein of the red blood cells. Anemia, which frequently develops during chronic infection, is due in part to this sequestration of iron. Furthermore, iron serves a critical role in several enzymes in the scavenging white blood cells: iron deficiency may thus create deficient functioning of these cells.

Infection in the gastrointestinal tract, which is frequently the case in malnourished children, often has direct effects on the intestinal mucosa that can alter its absorptive function. This malabsorption, which means that ingested food is used less efficiently, can persist long after the acute infection subsides. During some of these infections, excessive numbers of cells fall off the intestinal surface and are passed out of the body. Since each cell is a protein packet, this further depletes the body's protein stores and poses an additional problem—replacement of the lost cells. Other protein packets—pus cells-are mobilized to fight the infection, and they, too, are excreted along with intestinal cells.

As for cultural responses to infection, when a child has profound gastrointestinal symptoms and no appetite, his parents, whether in a developing country or an industrialized nation, often withdraw foods suspected of being difficult to digest. These usually include spices and condiments, but protein-rich foods are often included as well. At a time of increased protein loss from body stores and diminished efficiency of absorption from the intestinal tract, a greater than normal protein intake would be required just to maintain balance or simply to minimize losses. Yet just the opposite occurs.

In Central America, for example. the Indians prepare atole, a bland, watery drink made from corn. deeming it the only food fit to feed a sick child. In recent years a totally nonprotein cornstarch has been used for this purpose. As a volume replacement for real food, it is likely that cornstarch has precipitated many fatal cases of acute kwashiorkor: still, vitamin-supplemented cornstarch is actively promoted by commercial companies as a nutritious foodstuff. In our culture, too, the same kind of response occurs in the form of the tea and toast regimen to



"rest" the intestine. But some populations can afford this form of dietary indiscretion less than others.

Infection, then, is a stress on anybody. But for those of us who are well nourished and basically healthy, the stress is short-lived. Aided by an elaborate system of defense mechanisms, we can quickly recover and recoup our nutrient losses. The malnourished child is not so fortunate; not only does he suffer far more from such stress, but his protective mechanisms are also deficient as a result of his poor nutritional status. To understand this complex interaction, it is first necessary to look at the mechanisms themselves.

Surrounded as we are by organisms invisible to the naked eye, in fact, outnumbered in our human cell population by the aggregate number of bacterial cells in our intestinal tracts alone, we have evolved a variety of protective systems. Some mechanisms are entirely nonspecific, some

are exquisitely and elegantly precise.

The nonspecific mechanisms, although rarely considered, are very effective. The simple luxury of an intact skin, for example, represents a major barrier to invasion by potentially pathogenic bacteria that reside on the skin or that can be picked up by contact with infected people or contaminated objects in the environment. This is easily demonstrated by the frequency of infections that develop whenever the cuticle is broken, even in otherwise healthy, wellnourished individuals. Any nail chewer will confirm that paronychia is an occupational hazard.

The malnourished child, however, does not have an intact skin. Almost invariably, his skin is broken by fissures, sores, cuts, and ulcers—with oozing and crusting of serum and pus. These breaks in the integrity of the skin provide ready portals of entry for many types of bacteria.

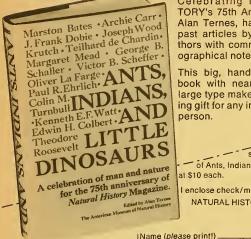
The mucosae that line the nose,

Weighing an average of 5½ pounds. babies in a Guatemalan village are small at birth and because they are poorly nourished, never achieve the average weight of children in developed countries. One baby developed whooping cough at nine months and gradually lost about two pounds. Although he recovered and began to gain weight about five months later, he never closed the gap in his growth curve. Such infections, which occur regularly in malnourished children, result in permanent stunting, if not early death.

throat, and upper respiratory passages are thinner and more delicate than the thick, keratinized skin surface, and these membranes require additional protective mechanisms. They are lined with ciliated epithelial cells bearing multitudes of motile hairlike projections, which beat in unison in a wavelike fashion, a pattern sometimes likened to "wind in a wheatfield." These cilia rapidly move particles away from the lungs toward the mouth and the outside world, thus minimizing the chance of inhaled particles reaching the sensitive lungs. Mucus secreted by specialized cells scattered along the membranes aids in this process. Bacteria, dust, and other pollutantsrolled up and packaged in little balls of mucus-are propelled up toward the mouth by the beating cilia. From there, they may be spat out or swallowed. We do not know for sure, but it seems likely that since this process depends on energy, nutritional deprivation could adversely affect the functioning of cilia.

Within the stomach these mucus balls, together with ingested and swallowed bacteria, encounter hydrochloric acid. The purpose of this acid is not simply to cause indigestion, as television advertisements would have you believe, but to create favorable conditions for the action of digestive enzymes and to kill many bacteria unable to survive an acid environment. During the recent cholera outbreak in Europe and the Middle East, investigators in Israel found that patients developing the disease had abnormally low gastric acid production. This allows greater numbers of

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live organisms to pass into the susceptible small intestine, where the greater the number of organisms, the greater the likelihood of disease. Malnutrition may lead to, and is frequently associated with, gastritis, which results in diminished gastric acid secretion. Thus, poor nutritional status could directly impair this important body defense.

Leaving the general protective mechanisms, we come to the body's circulating defense system, which is far more specific. This system involves four major cell types and several proteins that circulate in the blood. Known as the complement system, these substances augment the functioning of the four cell types: the T-lymphocyte (T-cell), the Blymphocyte (B-cell), the polymorphonuclear leukocyte (PMN), and the monocyte (MC). Like soldiers in an army, the cells have different jobs when confronted with an enemy, in this case, infectious agents, but their functions interrelate and, ultimately, they must work as a unit.

The B-cell, the workhorse of circulating immunity, makes anti-bodies-proteins in the blood or serum that antagonize foreign substances such as microorganisms-when stimulated to do so by contact with the inciting material. The T-cell cannot make antibodies, but responds to a specific stimulus by producing small protein molecules that encourage the activity of the other killer cells. Under proper conditions, the PMN and the MC recognize, ingest, and kill bacteria. Activated MCs, in fact, are called "angry monocytes," for they will ingest and kill almost anything they recognize as foreign, be it a different microorganism or an abnormal, malignant cell.

Perhaps the simplest system involves the PMN, a cell that is born and matures in the bone marrow, circulates briefly in the blood, and then passes out into the tissues; from there it is lost to the body via the urine and the intestinal tract. This passage is a one-way journey; the circulating cell pool represents the front line of defense, with the bone marrow a reserve force. In response to invading bacteria, particularly bacteria in tissues rather than those that circulate in the blood, PMNs must recognize that they are needed and move to the site of developing infection, a process called chemotaxis. Once at the site, the PMN must recognize the organism in order to ingest it (phagocy-

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tosis, literally, "eating the cell"). In order to be recognized, the invading organism must be prepared by a process called opsonization (from the Greek, "to buy victuals" or "to prepare for eating"). The process involves coating the bacterial cell with certain substances, opsonins, derived from the complement system or a specific antibody. Since many pathogenic bacteria are virulent by virtue of their ability to resist being phagocytized, opsonization is essential.

How does nutritional status affect this microbial world? Many of these responses are stimulated or influenced by the complement system. And this system is strongly affected by the body's state of nutrition. In a malnourished child, components of the complement system are deficient, adversely affecting chemotaxis, opsonization, and bacteria-killing systems. Even when there are normal opsonins and the offending organism is coated so that it can be recognized, the malnourished PMN seems to kill ingested bacteria more slowly.

This is a bigger problem than it may at first seem. To reduce the rate at which the PMN kills bacteria does not just add a day or so to the length of illness; rather, it can allow the disease to develop in the first place, instead of being stopped in its tracks before symptoms appear.

The T-cells, too, are exquisitely sensitive to nutritional insult. The malnourished child has fewer T-cells, and these function less effectively, which means that all defenses dependent upon them are markedly impaired. This type of response is particularly important in such infections as tuberculosis and typhoid fever.

As for the B-cells and the MCs, they may be relatively spared. In my laboratory, we caused animals to develop protein-calorie malnutrition, then studied the MCs in the test tube. We exposed them to certain pathogens and watched the MC-immune response, which was largely normal. But in the real test, in the intact animal, where MCs have to work in conjunction with T-cells and the complement system, both of which are markedly abnormal, they cannot function adequately. Since many of the mechanisms involved in the immune system have overlapping domains, small qualitative abnormalities in several areas can add up to a major problem.

An understanding of the interaction between malnutrition and infection is not simply an abstract exercise; it has therapeutic value in the pediatric wards where Maria and thousands of others like her are being treated. In the past, for example, a child hospitalized for protein-calorie malnutrition was immediately given iron to correct this deficiency. Yet if he had an infection, which was likely, this could be the worst thing to do. Since the iron-binding protein in a malnourished child is low, all iron added to the blood is freely available to the infecting organism, which may grow better and become more virulent as a result (like fertilizing a weedfilled garden). We now know that we must first replace protein before correcting for iron deficiency.

These findings also influence our understanding of disease prevention. Many countries have embarked on large, expensive, and well-intentioned programs of disease prevention through immunization of children. In theory, by vaccinating a child with live pathogens (which are, of course, attenuated), you cause his immune system to form antibodies to the agent. Thus, if he is exposed to the pathogen in the future, the successfully immunized child will not develop the disease. Such procedures have been responsible for wiping out most of the dreaded childhood infections—yellow fever, measles, polio, and others. Yet the malnourished child, with his immune deficiencies, may not be able to respond to these live pathogens in a normal fashion; if he is vaccinated, the organisms, which may live quite happily in his body for many years, could cause serious problems in the future.

Not only have we begun to understand that what is considered classical pediatric care in the developed countries may at times be inappropriate in the Third World, but studies in a Guatemalan village have also served to focus our attention on a new group. In the past, nutrition and health programs, including those of UNICEF and various charities, were aimed at school-age children, not because they needed such attention more than other

Food—its scarcity, its importance to developing children, its role in developing countries—has been called the problem of the century. With this article, Natural History introduces a new column, "The Web of Hunger," which, in a series of pieces to be published from time to time, will look at different aspects of this complex problem.

groups, but because they were logistically reachable. Focus on weanling diarrhea pushed concern back to the vulnerable preschool child. We now believe that the most important group to reach is the growing fetus. Contrary to the belief that the developing infant could successfully parasitize the mother for whatever nutrients were needed for growth, our studies show that newborns in the village are not normal—they are small at birth, weighing an average of 51/2 pounds, and nearly 20 percent show evidence of subtle intrauterine infection.

Although there are legal and ethical considerations in defining when "life" begins, it is certainly not at birth. The Chinese, recognizing this long ago, call an infant one year old at birth. It could be that intrauterine malnutrition and infection affect prenatal growth and birth weight. Birth weight, in turn, significantly affects the growing infant's development: the smaller the newborn, the greater the incidence and severity of postnatal problems. Here then is a new target group for health intervention-a group that can be reached through the pregnant woman, who is an identifiable and often reachable person in the community.

What then does all this mean? Obviously, the ultimate answers to problems of malnutrition and infection lie in efforts to feed the world's population, to improve hygiene, and to control environmental sanitation. Unfortunately, these are political questions more than they are medical problems. and realistically, their resolution will take a long time. It will require the active input of physicians and medical scientists to help politicians. economists, and development planners set proper priorities. Physicians must be heard, and to do this, we will have to leave the laboratory and enter the political arena.

Immediate steps can be taken in the form of improved sanitation, education, immunization programs to control infectious diseases, and proper therapy when prevention has failed but the entire public health approach must be reassessed, placing medica problems in the larger context of the ecology of poverty. To break the cycle of malnutrition and infection is a lofty goal, but if the Marias of Gua temala are to have the same chance: as the Lyssas of New York to reacl their full intellectual genetic poten tial, attainment of this goal is worth

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Posture Maketh the Man

Few scientists were ready to recognize the "missing link" when we found it

No event did more to establish the fame and prestige of The American Museum of Natural History than the Gobi Desert expeditions of the 1920s. The discoveries, including the first dinosaur eggs, were exciting and abundant, and the sheer romance fit Hollywood's most heroic mold. It is still hard to find a better adventure story than Roy Chapman Andrews's book (with the chauvinistic title) The New Conquest of Central Asia. Nonetheless, although it may be sacrilegious to mention it in this publication, the expeditions utterly failed to achieve their stated purpose: to find in Central Asia the ancestors of man. And they failed for the most elementary of reasons-we evolved in Africa, as Darwin had surmised fifty years earlier.

Our African ancestors (or at least our nearest cousins) were discovered in cave deposits during the 1920s. But these australopithecines failed to fit preconceived notions of what a "missing link" should look like, and many scientists refused to accept them as bona fide members of our lineage. Most anthropologists had imagined a fairly harmonious transformation from ape to man, propelled by increasing intelligence. A missing link should be intermediate in both body and brain-Alley Oop or the old (and false) representations of stoopshouldered Neanderthals. But the australopithecines refused to conform. To be sure, their brains were bigger than those of any ape of comparable body size, but not much bigger (see my columns of February 1974 and January 1975). Most of our evolutionary increase in brain size occurred after we reached the australopithecine level. Yet these smallbrained australopithecines walked as erect as you or I. How could this be? If our evolution was propelled by an enlarging brain, how could upright posture—another "hallmark of hominization," not just an incidental feature—originate first? In a 1963 essay, George Gaylord Simpson used this dilemma to illustrate

the sometimes spectacular failure to predict discoveries even when there is a sound basis for such prediction. An evolutionary example is the failure to predict discovery of a ''missing link,'' now known [Australopithecus], that was upright and tool-making but had the physiognomy and cranial capacity of an ape.

We must ascribe this "spectacular failure" primarily to a subtle prejudice that led to the following, invalid extrapolation: We dominate other animals by brain power (and little else); therefore, an increasing brain must have propelled our own evolution at all stages. The tradition for subordinating upright posture to an enlarging brain can be traced throughout the history of anthropology. Karl Ernst von Baer, the greatest embryologist of the nineteenth century (and second only to Darwin in my personal pantheon of scientific heroes) wrote in 1828: "Upright posture is only the consequence of the higher development of the brain . . . all differences between men and other animals depend upon construction of the brain." One hundred years later, the English anthropologist G. E. Smith wrote: "It was not the adoption of the erect attitude or the invention of articulate language that made man from an ape, but the gradual perfecting of a brain and the slow building of the mental structure, of which erectness of carriage and speech are some of the incidental manifestations."

Against this chorus of emphasis upon the brain, a very few scientists upheld the primacy of upright posture. Sigmund Freud based much of his highly idiosyncratic theory for the origin of civilization upon it. Beginning in his letters to Wilhelm Fliess in the 1890s and culminating in his 1930 essay on Civilization and Its Discontents, Freud argued that our assumption of upright posture had reoriented our primary sensation from smell to vision. This devaluation of olfaction shifted the object of sexual stimulation in males from cyclic odors of estrus to the continual visibility of female genitalia. Continual desire of males led to the evolution of continual receptivity in females. Most mammals copulate only around periods of ovulation; humans are sexually active at all times (a favorite theme of writers on sexuality). Continual sexuality has cemented the human family and made civilization possible; animals with strongly cyclic copulation have no strong impetus for stable family structure. "The fateful process of civilization," Freud concludes, "would thus have set in with man's adoption of an erect posture."

Although Freud's ideas gained no following among anthropologists, another minor tradition did arise to stress the primacy of upright posture. (It is, by the way, the argument we tend to accept today in explaining the morphology of australopithecines and the path of human evolution.) The brain cannot begin to increase in a vacuum. A primary impetus must be provided by an altered mode of life that would place a strong, selective premium upon intelligence. Upright posture frees the hands from locomo-

tion and for manipulation (literally, from manus = "hand"). For the first time, tools and weapons can be fashioned and used with ease. Increased intelligence is largely a response to the enormous potential inherent in free hands for manufacture-again, literally. (Needless to say, no anthroa pologist has ever been so naïve as to argue that brain and posture are completely independent in evolution, that one reached its fully human status before the other began to change at all. We are dealing with interaction and mutual reinforcement. Nevertheless, our early evolution did involve a more rapid change in posture than in brain size; complete freeing of hands for tool use preceded most of our evolutionary brain enlargement.)

In another proof that sobriety does not make right, von Baer's mystical and oracular colleague Lorenz Oken hit upon the "correct" argument in 1809, while von Baer was led astray a few years later. "Man by the upright walk obtains his character, writes Oken, "the hands become free and can achieve all other offices. . . . With the freedom of the body has been granted also the freedom of the mind." But the champion of upright posture during the nineteenth century was Darwin's German bulldog Ernst Haeckel. Without a scrap of direct evidence, Haeckel reconstructed our ancestor and even gave it a scientific name, Pithecanthropus alalus, the upright, speechless, small-brained ape-man. (Pithecanthropus, by the way, is probably the only scientific name ever given to an animal before it was discovered. When Du Bois discovered Java Man in the 1890s, he adopted Haeckel's generic name but he gave it the new specific designation Pithecanthropus erectus. We now usually include this creature in



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our own genus as Homo erectus.)

But why, despite Oken and Haeckel's demurral, did the idea of cerebral primacy become so strongly entrenched? One thing is sure: it had nothing to do with direct evidencefor there was none for any position. With the exception of Neanderthal (a mere geographic variant of our own species according to most anthropologists), no fossil humans were discovered until the closing years of the nineteenth century, long after the dogma of cerebral primacy was established. But debates based on no evidence are among the most revealing in the history of science, for in the absence of factual constraints, the cultural biases that affect all thought (and which scientists try so assiduously to deny) lie nakedly exposed.

Indeed, the nineteenth century produced a brilliant exposé from a source that will no doubt surprise most readers-Friedrich Engels. (A bit of reflection should diminish surprise. Engels had a keen interest in the natural sciences and sought to base his general philosophy of dialectical materialism upon a "positive" foundation. He did not live to complete his "dialectics of nature," but he included long commentaries on science in such treatises as the Anti-Dühring.) In 1876, Engels wrote an essay entitled, The Part Played by Labor in the Transition from Ape to Man. It was published posthumously in 1896 and, unfortunately, had no visible impact upon Western science.

Engels considers three essential features of human evolution: speech, a large brain, and upright posture. He argues that the first step must have been a descent from the trees with subsequent evolution to upright posture by our ground-dwelling ancestors. "These apes when moving on level ground began to drop the habit of using their hands and to adopt a more and more erect gait. This was the decisive step in the transition from ape to man." Upright posture freed the hand for using tools (labor, in Engels's terminology); increased intelligence and speech came later.

Thus the hand is not only the organ of labor, it is also the product of labor. Only by labor, by adaptation to ever new operations... by the ever-renewed employment of these inherited improvements in new, more and more complicated operations, has the human hand attained the high degree of perfection that

has enabled it to conjure into being the pictures of Raphael, the statues of Thorwaldsen, the music of Paganini. [Fashions in art may be as impermanent as those in dress; Engels's last two "paragons" are regarded as minor figures today.]

Engels presents his conclusions as though they followed deductively from the premises of his materialist philosophy, but I am confident that he cribbed them from Haeckel. The two formulations are almost identical, and Engels cites the relevant pages of Haeckel's work for other purposes in an earlier essay written in 1874. But no matter. The importance of Engels's essay lies, not in its substantive conclusions, but in its trenchant political analysis of why Western science was so hung up on the a priori assertion of cerebral primacy.

As humans learned to master their material surroundings, Engels argues, other skills were added to primitive hunting-agriculture, spinning, pottery, navigation, arts and sciences, law and politics, and finally, "the fantastic reflection of human things in the human mind: religion." As wealth accumulated, small groups of men seized power and forced others to work for them. Labor, the source of all wealth and the primary impetus for human evolution, assumed the same low status of those who labored for the rulers. Since rulers governed by their will (that is, by feats of mind), actions of the brain appeared to have a motive power of their own. The profession of philosophy followed no unsullied ideal of truth. Philosophers relied on state or religious patronage. Even if Plato did not consciously conspire to bolster the privileges of rulers with a supposedly abstract philosophy, his own class position encouraged an emphasis on thought as primary, dominating, and altogether more noble and important than the labor it supervised. This idealistic tradition dominated philosophy right through to Darwin's day. Its influence was so subtle and pervasive that even scientific, but apolitical, materialists like Darwin fell under its sway. A bias must be recognized before it can be challenged. Cerebral primacy seemed so obvious and natural that it was accepted as given, rather than recognized as a deep-seated social prejudice related to the class position of professional thinkers and their patrons. Engels writes:

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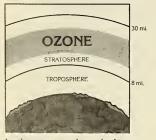
Fluorocarbons are liquids and gases used in refrigeration, for air conditioning, and as propellants in about half the aerosol spray cans sold in this country. Some say that these useful, normally safe compounds will cause a health hazard by attacking the earth's ozone layer. We believe this is an oversimplification.

The point is, to date there is no conclusive evidence to prove this statement. To understand, then, why there is a controversy, it is necessary to unsimplify the issue. We must treat the real world on its own terms, and they are complex.

The model that raised the question.

Ozone is continually created and destroyed by natural forces scientists are seeking to understand. The ozone depletion theory, based on a computer model of the stratosphere, was reported in 1974 by two chemists at the University of California.

This mathematical model calculates how fluorocarbons



in the stratosphere behave under the influence of a series of variables (such as temperature, altitude, sunlight, chemical concentration) to affect the ozone layer.

In order to estimate hypothetical reactions, and because little is actually known about the real ones, the modelers made a number of assumptions about the way the upper atmosphere behaves.

The unmeasured yardstick.

Before any judgments can be made using this model as a stratospheric yardstick, its accuracy must be determined.



Does it describe the real, three-dimensional world? To find this out, the validity of the modeler's basic assumptions must be determined.

Turning assumptions into facts.

Before a valuable industry is hypothesized out of existence, more facts are needed. To get these facts Du Pont and the other fluorocarbon manufacturers are funding independent technological investigations in universities and research laboratories. Under the direction of acknowledged scientific experts, this research is designed to either prove or disprove the assumptions most important to the computer case against fluorocar-

Some research has been carried out since the model

was first presented. Scientists now have a better idea of the accuracy of the assumptions in the model.

ASSUMPTION: The ozone-depleting reaction with chlorine from fluorocarbons takes place at a rate that demands an <u>immediate decision</u> on fluorocarbon use.

FACT: Recent determinations of reaction rates disclose that the ozone/chlorine reaction actually takes place at a slower rate than that assumed by the model. In addition, the same research has shown that the reaction of chlorine with stratospheric methane proceeds at a faster rate. Since this reaction tends to remove chlorine from the ozone laver. the net effect of both reactions is to lessen the originallycalculated impact of fluorocarbons. In fact, the impact was overstated by 300%.

RESEARCH: To guide future measurements of stratospheric reactions, a laboratory program has been funded to measure the reactions of chlorine compounds and ozone under simulated stratospheric conditions.

Most scientists agree there is time to conduct the research needed to settle the controversy one way or the other... before a final decision is made on fluorocarbon production and use.

ASSUMPTION: There is no other way to get fluorocarbons out of the atmosphere except by the ozone-depleting reaction.

FACT: One well-known class of chemical reactions not considered in the model is that of chlorine compounds in the

answered one way or the other. Du Pont.

atmosphere in heterogeneous reactions.

In an article in SCIENCE (Feb. 14, 1975), Professors S. C. Wofsy, M. B. McElroy, and N. D. Sze of Harvard University caution that "If additional removal processes could be identified... or if additional sinks could be identified for stratospheric odd chlorine, the atmospheric and biological impacts of [fluorocarbons] would be reduced accordingly."

RESEARCH: Atmospheric chemistry involving ion molecule reactions has been described in recent months by several investigators. Reaction rates with ion molecules are known to be extremely fast and are believed to occur primarily in the lower stratosphere.

Thus, ion molecules could react with fluorocarbons, allowing them to be removed from the atmosphere.

ASSUMPTION: Fluorocarbons are the only significant source of chlorine available for interaction with ozone in the stratosphere.

FACT: Many chlorine-containing materials are present in the atmosphere in varying concentrations. Of particular significance, large amounts of methyl chloride and carbon tetrachloride have been discovered in the troposphere and stratosphere.

In addition, new calculations on the injection of gaseous chlorine compounds into the stratosphere from volcanic eruptions have shown this as a <u>significant</u> contributor of chlorine not taken into account by the model.

RESEARCH: Scientists are completing an inventory of

chlorine-containing compounds in the atmosphere. It must be determined how nature deals with chlorine from these natural sources, before it can be shown that chlorine from fluorocarbons might pose a threat to the ozone layer.

Additional research.

A fluorocarbon industry research program is funding the development of a computer model that will better reflect the complex chemistry of the stratosphere.

In addition, other studies are under way to broaden our understanding of the total ozone production/destruction balance. These will concern themselves with other stratospheric reactions affecting

A panel of highly qualified academic scientists will advise on the technical programs covering various facets of the problem. This panel of independent experts will review the projects, providing a critical opinion on the pertinence of each, the probability of their success, and the completeness of the overall investigation.

Conclusion.

Much more experimental evidence is needed to evaluate the ozone depletion theory. Fortunately, as most scientists agree, there is time to gather this evidence. Du Pont has joined with other fluorocarbon manufacturers to provide funds for work by independent university scientists. Governmental agencies are also con-

ducting research to help in the assessment of the theory.

Should the theory be proven correct after all the evidence is in, Du Pont, as we have stated, will stop the manufacture and sale of the offending compounds.

In the meantime, we believe that to act without the facts—whether it be to alarm consumers, or to enact restrictive legislation—is irresponsible. Final decisions cannot be made with only the information at hand.

The independent research described above is presently being carried out by scientists at the following institutions: Cambridge University—

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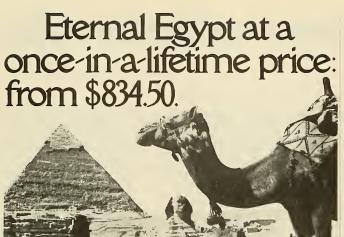
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All merit for the swift advance of civilization was ascribed to the mind, to the development and activity of the brain. Men became accustomed to explain their actions from their thoughts, instead of from their needs. . . . And so there arose in the course of time that idealistic outlook on the world which, especially since the downfall of the ancient world, has dominated men's minds. It still rules them to such a degree that even the most materialistic natural scientists of the Darwinian school are still unable to form any clear idea of the origin of man, because under that ideological influence they do not recognize the part that has been played therein by labor.

The importance of Engels's essay does not lie in the happy result that Australopithecus confirmed a specific theory proposed by him-via Haeckel—but rather in his perceptive analysis of the political role of science and of the social biases that must affect all thought.

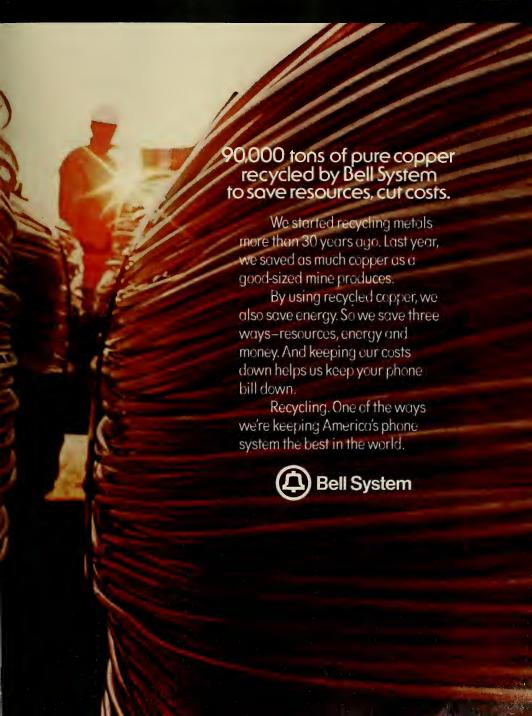
Indeed, Engels's theme of the separation of head and hand has done much to set and limit the course of science throughout history. Academic science, in particular, has been constrained by an ideal of "pure" research, which in former days barred a scientist from extensive experimentation and empirical testing. Ancient Greek science labored under the restriction that patrician thinkers could not perform the manual work of plebeian artisans. Medieval barber-surgeons who had to deal with battlefield casualties did more to advance the practice of medicine than academic physicians who rarely examined patients and who based their treatment on a knowledge of Galen and other learned texts. Even today, "pure" researchers tend to disparage the practical, and terms such as "aggie school" and "cow college" are heard with distressing frequency in academic circles. If we took Engels's message to heart and recognized our belief in the inherent superiority of pure research for what it is namely social prejudice-then we might forge among scientists the union between theory and practice that a world teetering dangerously near the brink so desperately needs.

Stephen Jay Gould teaches biology. geology, and the history of science at Harvard University.





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Strategies of Reproduction

by R. D. Martin

The birth of only a few offspring has advantages for most primates, including man

Some of the most basic structural and behavioral features of mammals concern reproduction, but reproductive patterns are seldom featured in discussions of mammalian evolution. This is curious because the mammals as a group earn their name from the universal possession of mammary glands and the associated occurrence of suckling behavior.

In fact, it has long been customary to divide the class Mammalia into three reproductive subclasses: the Prototheria (egg-laying monotremes), the Metatheria (marsupials), and the Eutheria (placental mammals). These three clear-cut divisions reflect the different degrees to which the fertilized egg develops within the mother before emergence. When all members of a particular mammalian group share a common pattern, this is a strong indication of an ancestral adaptation. All modern placental mammals, for example, exhibit a placental attachment of some kind during embryonic development. This permits the embryo to develop within the mother, so that live birth, or viviparity, occurs, rather than egg laying (oviparity). Therefore, a reasonable supposition would be that the ancestral placental mammals also exhibited this characteristic or something very close to it.

Reproductive characteristics are as fundamental to mammalian evolution as dental, cranial, or skeletal charac-

ters. Fossil jaws and teeth indicate that placental mammals had emerged approximately 100 million years ago. Because it also seems evident from reproductive patterns alone that all living placental mammals shared a common ancestor, we need to understand the evolution of reproduction in these mammals in order to interpret mammalian history.

One reason for the relative neglect of reproduction in recent work on mammalian evolution is that, at first sight, little can be learned from the fossil record. Paleontologists often imply that the only valid approach to the study of mammalian evolution lies in interpretation of hard parts preserved in the scanty fossil record. This approach, however, is also speculative, with the additional drawback that relatively few characteristics are preserved for consideration.

The exclusive advantage of a correctly interpreted fossil record is the establishment of an approximate time scale for evolution. A fossil fragment from a mammalian skeleton is nothing more than a geologic specimen

Unlike most simian primates, which usually give birth to a single young, the golden, or lion-headed, marmoset regularly has twins. This may be due to the animal's evolution in an unstable environment, where larger litters are advantageous.

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until it is recognized as "mammalian" on the basis of comparison with some living mammalian species. Constructing hypotheses about the evolution of reproductive patterns in mammals through analysis of anatomical, ecological, and behavioral elements of present-day species is thus an equally legitimate undertaking.

The evolution of reproduction is of special interest in the case of the primates (prosimians, monkeys, apes, and man), since elaborate maternal care is central to many outstanding features of this particular mammalian group. To determine what factors might have influenced the evolution of primate reproduction, we must first identify characteristics that are typical of living primates.

A striking, universal attribute of nonhuman primates (excluding the tree shrews) is that their infants are physically well developed at birth. The eyes and the external ear channel are open at birth or soon afterward, the fur is well developed, and locomotion is sufficiently advanced for the young to clamber about.

This attribute of advanced physical development at birth is linked with several other characteristics to form a precocial complex. Following a long gestation period, primates typically have small litters (in most cases only one infant per birth), the subsequent lactation period is of long duration, sexual maturity is reached only after an extended period of development, and the maximum life-span is considerable—at least a decade and increasing with body size.

The small litter size is matched by a small number of teats, with most primates having one pair. In addition, the brain size of both infants and adults is moderate to large, in comparison with other mammals.

Of course, most of these featuresespecially the gestation period and the brain size-vary systematically with body size, and such scaling effects must be taken into account in all comparisons. Nevertheless, it is obvious that all living primates exhibit the precocial complex, amounting in practice to a low reproductive turnover. Since virtually all primates have well-developed patterns of social organization in addition to, and dependent upon, their elaborate parental care, the over-all trend in primate reproduction has clearly been toward quality rather than quantity. Fewer offspring are produced, but the few that are born are well cared for



and are likely to live for a long time.

Adolf Portmann, who conducted a great deal of the systematic work on mammalian reproductive characteristics, found that mammals generally tend to fall into two distinct groups. Some, like the primates, are precocial; others exhibit an altricial complex. Altricial mammals typically build nests to shelter their offspring and have relatively large litters of infants, which are poorly developed at birth (hairless, almost helpless young with their eyes and ears sealed by membranes). Gestation and lactation are of brief duration, sexual maturity occurs at an early age, and life-spans are typically short. Finally, altricial mammals have relatively small brains and lack elaborate social systems.

Of course, there are intermediate

groups and various exceptional cases that must be considered on their own merits, but it is notable that each mammalian order tends to exhibit predominantly one complex-either the precocial or the altricial. For example, insectivores (including tree shrews), rodents, and small-bodied carnivores are, in most instances, altricial; while primates, ungulates, cetaceans, and hyraxes are, almost without exception, precocial. Smallbodied mammals are generally altricial, whereas medium-sized to large mammals are generally precocial.

As observations of fact, all of these points are valuable, but it would be far more instructive to have a cohesive explanation for this divergence into two basic reproductive complexes in mammals. The common thread running through all of these

A troop of baboons searches for food near Lake Manyara, Tanzania. When the food supply of a species is stable, lower rates of reproduction predominate.

characters is reproductive turnover. This is revealing, since natural selection amounts to differential survival of offspring. It is therefore highly likely that there are two essentially different reproductive strategies involved, in the sense that natural selection has generally favored two contrasting responses to the problems of population replacement and colonization of new habitats.

The divergence also applies to





basic features of reproductive physiology; mammals with the precocial complex usually have long estrous cycles (periods of fertility) and exhibit spontaneous ovulation, whereas those with the altricial complex tend to have short estrous cycles with sharply defined times of maximum fertility and show some link between ovulation and the act of mating.

Interpreting the evolution of the es-

Riding through its future habitat

while clasped to its mother's

fur, a young spider monkey, left, is in an ideal position

to learn survival techniques.

The olive baboon infant, below, will develop much of its

complex social behavior from

a close physical relationship

trous cycle is difficult, since under natural conditions most female mammals tend to exhibit a pregnancy cycle when they are in breeding condition. However, a short interval between successive ovulations in the absence of pregnancy really amounts to an adaptation for high reproductive turnover. If the interval between successive ovulations is brief, a female will soon become receptive again, should mating happen to be infertile on any one occasion.

The actual mechanism of ovulation is also somewhat difficult to interpret in terms of evolution. In any female mammal, one or more ripening follicles in each ovary will be mature when the female is receptive to mating. After the egg is released from the follicle (ovulation), the residual tissue of each ruptured follicle forms a corpus luteum, which produces progesterone to support the ensuing pregnancy.



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typically erupt spontaneously at some fixed time, whether or not mating has taken place. The corpus luteum forms automatically and persists for some time before the next ovulation occurs. In altricial mammals, on the other hand, ovulation itself may depend on stimulation from the act of mating (with subsequent automatic formation of the corpus luteum) or ovulation may occur spontaneously but mating must occur before an active corpus luteum is formed. In either of these situations, the female will rapidly return to estrus if mating fails to take place, since no long-lasting corpus luteum forms and ovulation is not inhibited. Once again, the altricial mammals are clearly adapted for a high reproductive turnover.

The search for a general evolutionary explanation for the distinction between altricial and precocial mammals may perhaps be explained through the ecological concept of rand K-selection proposed by Robert MacArthur and Edward Wilson. Briefly, their theory suggests that in an environment where there is little crowding and where food is relatively abundant, r-selection will favor those animals that harvest the most food and rear the largest families, that is, those with a higher population growth rate. This applies even if food is gathered wastefully, as natural selection will favor productivity in such a situation. By contrast, when there is intense competition for food and a given species population is consistently close to the carrying capacity of the environment, K-selection will favor those animals that can replace themselves with the lowest possible intake of food. Efficiency in the conversion of food into offspring is selected for, since in this case, natural selection favors adaptive variations that serve to increase the carrying capacity of the environment.

According to this theory, if reproductive rates are the same, a large-bodied species consuming a given range of foods should reach the carrying capacity of those foods in a given environment more rapidly than a small-bodied species consuming the same foods. Therefore, efficient use of environmental resources is demanded of large-bodied species.

In principle, high rates of reproduction should predominate in situa-

tions where there are considerable fluctuations in the food supply, while more efficient, lower rates of reproduction should predominate where the food supply is relatively stable. Obviously, the two types of selection are opposite ends of a spectrum, and intermediate rates of reproduction must occur. However, there could well be a general two-way split that would match the distinction between altricial and precocial mammals.

Naturally, in discussing the course of mammalian evolution over the past 100 million years, one cannot begin to encompass long-term patterns or variation in ecological factors (for example, consistency of food supply). Nevertheless, some broad generalizations can be made.

First, it has been pointed out by MacArthur that tropical rain forest conditions would favor K-selection, while more seasonal and unpredictable environments would favor r-selection. In fact, the great majority of living primates live in tropical or subtropical forest conditions (this also applies to all well-established fossil primate species).

The nearly universal occurrence of the precocial complex among living primates indicates that the early primates must have undergone a considerable period of evolution under relatively stable conditions of food supply and competition. Adaptations during this period would have continued to influence subsequent evolutionary developments. One can suggest that the ancestral primates, which were most probably arboreal, were initially adapted for living in fairly stable tropical forest conditions with little climatic variation over the year. The precocial complex characteristic of living primates can therefore be regarded as an outcome of a reproductive strategy involving efficiency of exploitation of available food sources rather than high reproductive turnover. A relatively large brain size and a long period of mother-infant interaction, which permits social learning of such aspects of the environment as appropriate food sources, combined with the behavioral flexibility of a long-lived adult, would have contributed to the success of such a strategy.

The vast majority of living primates typically have only one infant





at birth, which is usually carried on the fur of a parent (in most cases, the mother) for some time after birth, rather than being left in a nest. Here, the grasping big toes—adapted for arboreal locomotion on relatively fine supports-enable the infant to clasp the parent's fur. Riding along in this way, the infant is ideally situated to learn the techniques needed for future efficient exploitation of the habitat; and there is an additional result in that primate infants suckle "on demand" rather than on a schedule decided by the mother. Unlike many other mammals, primate mothers typically suckle their infants with great frequency, both during periods of activity and while sleeping. This intimate contact with the mother increases the infant's chances of survival and also provides the basis for developing social behaviors.

Most primates do not build nests. This is true of almost all species now inhabiting tropical rain forest areas. Although the great apes are known to construct sleeping platforms every night, the only primates to build nests at fixed sites are the bush babies and some of the smaller, nocturnal lemurs of Madagascar. The majority of these small, nest-building prosimian species occur in dry forest areas. The dry forest bush babies and the dwarf and mouse lemurs are also the only prosimians that commonly have multiple litters (two to three infants) and produce more than one litter per year. Both features would be expected as adaptations to increased reproductive turnover, perhaps representing a secondary shift back to r-selection. This interpretation fits well with other evidence that the common ancestor of the bush babies and the mouse lemurs was adapted for relatively dry conditions. It might also explain the apparent paradox that bush babies and various nocturnal lemurs have precocial infants, just like other primates, yet construct nests.

It is apparent that the early pri-

Social organization among olive baboons is dependent on elaborate maternal care which, in turn, is dependent on low reproductive turnover.

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mates became channeled toward low reproductive turnover. One question that remains is, Were the earlier ancestral placental mammals altricial? as is generally assumed (mainly because modern altricial insectivores, such as the hedgehog, are widely taken as a model for ancestral mammals).

Portmann has pointed out that pre-

cocial mammalian species, such as the primates, seem to reflect an altricial ancestry in that their eyelids fuse together in development, as if in preparation for birth into a nest, and then reopen again at birth. Thus, although the primates can all be traced to an ancestor with precocial infants, the ancestral primate was probably derived from an earlier ancestral mammal with altricial infants.

It is also significant that the early mammals were probably small bodied and undoubtedly had relatively tiny brains, both of these features being typical of modern altricial mammals. Thus, it seems reasonable to conclude that the ancestral placen-



tal mammals were altricial, subjected primarily to selection for high productivity, and that one of the major shifts in the early stages of primate evolution was toward precocial patterns, under the influence of selection for efficiency in reproduction.

However, it should not be forgotten that all of these features are relative. A combination of viviparity and elaborate maternal care would itself be associated with reduction in reproductive turnover, when compared with a pattern of multiple egg laying. There was undoubtedly a gradual decrease in reproductive turnover as fishlike ancestors gave rise to the first terrestrial amphibians, as these gave

rise to the reptiles, and as the reptiles, in turn, gave rise to the mammals. Throughout the course of vertebrate evolution, there may have been a differential selection for more efficient and hence lower rates of reproduction in some species and higher reproductive turnover in others. Indeed, it is interesting to reflect that the concept of the phylogenetic scale, which has been so helpful when used carefully in discussing evolution, refers to a spectrum of increasing complexity in living organisms that is matched by a reduction in reproductive turnover. Man and the other primates lie at one extreme of this spectrum.

The establishment of the precocial complex among the primates provided much of the basis for human evolution, essentially because of original adaptations for low reproductive turnover. But this very feature of low fecundity has placed the primates, other than man, among the mammals most vulnerable to extinction. In the absence of natural checks, the human population is continuously increasing in numbers at the expense of the forest areas containing our primate relatives. On the one hand, removal of stable ecological conditions through technological advances has led to a population explosion in the most advanced primate species. On the other hand, disruption of the relatively stable forest conditions to which most other primate species are adapted must ultimately lead to the extinction of some of them. Primates as a group are not adapted for rapid colonization or recolonization, and the larger-bodied species are necessarily the most threatened because of their lower reproductive rates. Environmental stability was probably a key factor in primate evolution; the loss of such stability could be a key factor in primate extinction.



Efficient use of resources is demanded of such large-bodied animals as the mountain gorilla, a primate living close to the carrying capacity of its environment. Such efficiency results in fewer offspring, enabling more to survive.

D. Fossey, Bruce Coleman, Inc.

Connubial Cannibalism

by E. Jaediker Norsgaard

The female's postmating consumption of the male is entirely in the interests of species survival

The practice of cannibalism is repugnant within most human societies, even as a last resort to prevent starving to death. It is, however, an extremely efficient survival mechanism among a number of insect species. The predatory larvae of the owlflies (ascalaphids)-large, dragonflylike insects fairly common in the South and Southwest—practice it at times. Some species of termites eat their own wounded and crippled, in effect recycling those individuals no longer useful to the colony. Polistes paper wasps will eat their pupae that fail to complete their development at the end of the season, precisely the time when other food is scarce and when the young queens need nourishment to carry them through their winter hibernation.

The most intriguing example of insect cannibalism, however, is the devouring of a male praying mantis by the female with whom he has just mated. In the absence of this behavior, and to the detriment of the species, an egg-laden female might not find sustenance to carry out the reproductive tasks ahead of her.

Of the more than 1,500 mantid species known throughout the world, most are found in the Tropics. At least nineteen species live in this country, mostly in the southern states. The most common native species is the Carolina mantis, Stagmomantis carolina, which is about two inches long.

Two introduced species are common in the northern United Statesthe two-inch-long European mantis (Mantis religiosa) and the four-inchlong Chinese mantis (Tenodera aridifolia sinensis). Both species arrived accidentally with plants imported by

nurserymen toward the end of the

nineteenth century.

In the spring, from 50 to 300 minuscule mantids wrapped in membranous sacs wriggle out of each overwintering egg case, constructed on a twig or weed stem by an adult female the previous fall. The young initially dangle downward in a mass from silken threads suspended from the egg case. Soon they struggle out of their sacs and climb over each other to twigs where they rest while their first exoskeleton hardens. At this stage they are especially vulnerable to predation by ants.

The newly hatched nymphs look like miniature adults, except that they are pale and wingless. Confined to a cage, nymphs will begin to eat each other within a few days. In the natural state, however, they soon scatter and take up their solitary, highly predacious lives, blending into leafy backgrounds where they wait to catch in-

sects that pass close by.

At first mantids attack only small insects such as fruit flies, but as they grow, they prey upon caterpillars, beetles, wasps, and other sizable insects. One adult female Carolina mantis consumed ten German cockroach adults and a roach egg case in two and a half hours, far above the average food requirement.

The mantid's necklike prothorax is topped by an angular head that can rotate at least 180 degrees. Two large and bulging compound eyes made up of thousands of facets enable mantids to detect the slightest movement. Between the compound eyes a triad of small, simple eyes of one facet each are thought to respond to changes in light intensity. So specialized are its eyes for detecting movement that a mantid will react to a moving insect two feet away, while remaining unaware of another, much nearer one if it remains motionless. However, if a shadow or an object comes between



a mantid and an insect or if the insect that first attracted the mantid's attention remains immobile for a long time, the mantid may lose sight of it.

I have watched week-old mantids eating aphids and attacking small inchworms that lowered themselves on silken threads from the leaves above. As a worm descended, the waiting mantid moved below it to within striking distance, then usually waited until the inchworm moved again, however slightly, before shooting out its forelegs with lightning rapidity to capture the worm.

The mantid's stout, powerful forelegs are armed with a double row of spines. When the femur (third segment) and the tibia (fourth segment) are flexed, the prey is firmly grasped between the facing spines and held there while it is torn apart by the mantid's strong mandibles and eaten.

Mantids spend all summer preying upon insects, periodically molting their exoskeletons, which are replaced with fresh, larger ones that can accommodate their growth. This also enables the mantid to exchange some of its green color for brown to match the fall foliage. About ten days after

the final molt, a male mantid reaches maturity and begins to seek a female. A scent attractant secreted by the female can lure a male from a distance of up to 325 feet. No dance, serenade, or display enlivens his courtship. Rather, the male concentrates his efforts on approaching, unnoticed and unannounced, the larger, more voracious female. This can take minutes or hours.

Experimenting with European mantids, K.D. Roeder of Tufts University observed mature males and females placed together in large cages. Roeder found that upon first seeing a female, the male immediately "freezes" in the position of that moment, even in the act of raising a leg, and may remain in the same position for several hours. If the female detects his presence by even a slight movement, she may advance, grasp, and devour him as she would any other prey.

Only when her attention is elsewhere—grooming herself or catching other insects—can the male creep safely toward her with almost imperceptible movements. One might theorize that the most cautious males,

surviving to fertilize a number of females, may have led to the evolution of this negative type of courtship.

The approach is usually made from behind. When the male is inches away, he flies or, half opening his wings, jumps onto the female's back, clasping her with the tibiae of his forelegs, which fit into small grooves in front of her wing bases.

Having mounted the female, the male becomes very active. His abdomen, which in the proper mating position lies a little to the right of the female's, bends around in a curve to the left, so that his genitalia are carried around the left side of the female's wings and abdomen and aimed forward toward her ovipositor, or egg-laying organ. Throughout this activity, the female shows no sign of awareness.

After repeated probing, the ovipositor valves separate and mating takes place, probably with some active participation by the female: The pair remain together for several hours and the female may walk around during part of this time.

In a natural setting, rather than in the confines of a cage, I have seen a





male fly to a female from a distance of one foot. She was jostled as he landed slightly too far back on her back, but he immediately crept up and clasped her correctly. Had he gripped her by the head or landed across her back or in any other abnormal posture without correcting it at once, she might have quickly turned and killed him. When a male achieves the correct position, however, he is not molested.

A female is less likely to attack a male if she is feeding. Roeder states that an attack appears to depend upon the female's state of nutrition as well as her detection of the male's movements during his approach. He also, believes that captivity or disturbance of the couple promotes an attack before copulation.

If females do attack the males before mating takes place, the future of the species would appear to be jeopardized. This threat to the reproductive process, however, seems to have been anticipated by a curious reflex mechanism. The female usually seizes the male by his head or his forelegs and these are eaten first. Amazingly, a headless male is still able to mate successfully. The loss of his head is followed within a few minutes by intense and continuous copulatory movements-the typical bending of the abdomen in a modified S shape with its tip curved around to the left. At the same time, he slowly turns in an arc as the third and, to a lesser extent, the second leg on one side of his body are extended and flexed. The legs on the other side assist by pushing during the extensions. Unless the female is holding him too far back, these persistent sideways and rotary walking movements swing him around beside the female and up on her back. She makes no attempt to dislodge him and normal copulation follows.

This remarkable adaptation was explained through experiments on the sexual reflexes, in which various parts of the nervous system were surgically removed. The autonomous nerve center responsible for the reflexes is situated in the last ganglion, or mass of nerve cells, toward the end of the abdomen. If the abdomen and thorax are separated, copulatory movements always occur in the isolated abdomen. Sideways and rotary

walking movements also occur, but only for a short while, indicating that they are not as dependent on the last abdominal ganglion as are the copulatory movements.

These sexual reflexes are inhibited by a center in the subesophageal ganglion, a mass of nerve tissue in the head. When the male's head is eaten. the subesophageal ganglion is destroyed, thus removing the center that inhibits copulatory movements. In intact males, this inhibitory effect is counteracted, in some yet-unproved way, only upon contact with the female. Possibly the tactile sensation of the female body neutralizes the inhibitory center in the subesophageal ganglion. Experiments with various other insects, including the cockroach, have suggested similar auton-

In this sequence of a female devouring a male, the male typically shows no resistance. The process may take up to several hours.

Camobell Norspaard





omous local nerve patterns, but their functioning in mantids is a special modification of adaptive value.

After mating, the intact male shows little inclination to escape. The female's cannibalistic attack, however, is not inevitable and many males survive to mate again with the same or with other females.

Early last October, I discovered a Chinese mantis couple mating in a barberry hedge. After some hours, the male dismounted and was about ten inches away from the female. A few hours later they were still the same distance apart when the male moved slightly and the female responded by turning her head. She then walked toward him purposefully and paused. Suddenly her spiked forelegs reached out and clamped him in a jackknifelike vise. He flinched and his wings fanned out and fluttered.

Utilizing the male, whose life cycle is at an end anyway, is of great survival advantage to the female, especially in climates where the coming of late autumn means a scarcity or absence of live insect food. Her abdomen is heavy with hundreds of eggs, and she needs time and energy to make one or several egg cases, after which she will soon die.

I watched the female in the barberry hedge nibble at parts of the male's forelegs, literally disarming him. Soon she started eating his head-first the left emerald-green eye; then the right. After his head and part of his prothorax were eaten. I noticed his abdomen beginning the reflex bending movement of copulation. The female ate without stopping, grasping him around the thorax; his legs were extended in the air. One wing dropped off. By the time the afternoon light had waned, all that was left of the male were his wings and four slim green legs.

Unlike the cockroach, its closest relative, the mantid has been increasingly recognized for its valuable ability to control destructive garden insects. Biological supply houses now sell mantid egg cases to gardeners.

Satoshi Kuribayashi, Orion Prass







The Beautiful Blue Devil



by Noel D. Vietmeyer

All but indestructible, the water hyacinth competes with man for use of the world's waterways

One of the most successful colonizers in the plant world, the water hyacinth has spread within a hundred years from its home base in South America to at least fifty countries around the globe. Brazil is thought to have been its place of origin. By the 1880s it had reached North America. Early in this century it appeared in India; in the 1950s it was discovered in several African waterways; and in the 1960s it began plaguing Australia and Central America. Today, many of the world's major rivers are partly covered by water hyacinth-the Mississippi, the Nile, the Ganges, the Zambezi, the Congo, the Amazon, and the Mekong, to name a few.

The hyacinth exploits its freshwater habitat to the fullest, uses solar energy efficiently, and is enormously productive. It propagates by several mechanisms and adapts to changing climate and water quality. Amazingly robust, the hyacinth can even convert from an aquatic plant to a terrestrial one if its waterway dries up.

The water hyacinth is a beautiful organism, and its beauty has largely been the cause of its dispersion. People spread the plant: people captivated by its flowers and floating rosette of green leaves. Japanese entrepreneurs introduced it to the United States at the Cotton States Exposition of 1884 in New Orleans. The attractive plants—collected from the Orinoco River in Venezuela—evidently produced an esthetic reaction in the Japanese exhibitors, who gave away

To clear waterways in Sri Lanka, water hyacinths are pulled out manually. The plants are then used to make compost for growing vegetable seedlings.

single hyacinth plants as souvenirs.

But the water hyacinth never stays single for long. In the fishponds of southern cotton plantations its vigor quickly showed, and it rapidly overran the South. Eleven years after the Exposition, the sluggish Saint Johns River in Florida-600 miles from New Orleans—had hyacinth colonies that extended as much as 200 feet from each bank along a 100-mile stretch. During the summer of 1896 gale-force winds drove the hyacinth mass upstream, causing a 25-milelong blockage. Florida's logging industry-then a major businessfolded because hyacinth clogged the waterways. Logs could no longer be floated to the mills and no other transportation was available. In 1897 the state of Florida appealed to Congress for disaster relief.

Another example of how humans spread the hyacinth took place across the world in Siam (now Thailand). Beguiled by the plant's flowers, the wife of King Rama V in 1901 brought a water hyacinth back from Java to the royal palace in Bangkok. Its progeny were carefully managed in decorative pools on the palace grounds, but some years later a flood carried them into the klongs, or canals, of the city. There, untended, they flourished in the steamy, year-round heat; today the water hyacinth is a ubiquitous sight throughout Bangkok.

Despite its current prevalence, the water hyacinth was not even mentioned in botanical literature until the German botanist and physician Karl von Martius noted it in 1824, after a scientific expedition to Brazil. It could not have been widespread in the New World nor could it have been a pest or it would have been recorded centuries earlier. Even now in the South American countries of Brazil, Guyana (formerly British Guiana), and Argentina, it does not compete seriously with man because indigenous insects, viruses, and other natural enemies restrain its growth. But once moved from its native habitat, the plant becomes liberated.

The water hyacinth is one of seven species that make up the genus *Eichhornia*—named in the 1840s for J. A. Eichhorn, Prussia's minister of education, who was also a patron of horticulture. Six of the species are terrestrial plants. Only the water hyacinth,





Almost anything can be bought from a boat in Bangkok's narrow canals, or klongs. But these days, buyers and sellers must fight through the encroaching water hyacinth to reach the city's floating markets.

E. crassipes, goes on rampages. Only E. crassipes has developed the pronounced, spongy, swollen petioles, or leafstalks, that allow it to float. The petioles free the water hyacinth from a terrestrial grip and give it the ability to move. It is often seen bouncing along in the main current of a river and eddying into backwaters.

The plant's leaves act as sails, and driven by wind, E. crassipes has even been known to travel upriver against the current. In lone plants the base of each petiole is inflated with air sacs, forming a float with an internal structure similar to that of the foamed plastic material used to make buoyant beach toys. The rosette of petioles creates a circle of floats that prevents the plant from capsizing. When the plants are crowded together, however, the petioles are less swollen and grow tall and slender. In this way an acre can be packed with 180 tons of hyacinths.

Water hyacinth roots hang in the water. Black and hairlike, they are arranged in a feather pattern on slender rootstalks. The airy white or lavender flowers, borne on a spike, rise from the center of the plant. Their purple-veined petals have yellow, diamondlike centers on their upper lobes. Although the cluster of two to thirty-eight flowers bears a vague resemblance to the flower of the common garden hyacinth, the two plants are not related.

If after being open for forty-eight hours the flowers are not pollinated by insects, self-pollination takes place. For the next three weeks the tiny black seeds mature and the flower spike bends downward. When the fruit capsule splits, the seeds are cast into the water. The seeds, numbering as many as forty-five million per acre, are the only part of the water hyacinth with a specific gravity greater than one. They sink to the bottom mud where they can remain viable for as

long as fifteen years. Thus, under much of the world's freshwater there are billions of dormant water hyacinths waiting to spring to life.

This source is, however, only a backup reproductive system. The water hyacinth reproduces mainly in a vegetative, or nonsexual, manner by means of a slender horizontal runner, called a stolon, that it sends out across the surface of the water. As the stolon grows, a new plant forms at its tip, and in a matter of days a parent is surrounded by offspring. As their leaves and roots develop, the offspring begin sending out their own stolons to form a third generation. In one widely reported observation in Louisiana, two parent plants were surrounded by 300 offspring in twenty-three days and by 1,200 after four months. In the wild, water hyacinth plants can double their number within ten days. Under favorable conditions, 10 plants can multiply to 600,000 and overspread an acre of water in only eight months.

The hyacinth's growth is exerted sideways, not vertically as in most plants. Its aquatic environment provides it with lateral space. Arranged in a single rosette, its seldom-shaded leaves are unusually well shaped and spaced for capturing sunlight. Because of these factors, green rafts of hyacinth expand rapidly and inexorably over the water. Then winds, waves, and currents stretch and fracture the interlinking stolons; when these rot away, the rafts split apart, freeing sections that can be several acres in area. The freed colonies thrust relentlessly across a lake or down a river, ever growing, ever splitting into still more colonies. In enclosed waters the rafts merge into a continuous shore-to-shore mat. With further reproduction, the mat thickens and tightens until it is difficult to perceive the water beneath it. Visitors to southern states often drip through hotel lobbies after walking into what they took for a green "field" to pick the enticing flowers.

The water hyacinth is a sturdy plant. Its core is a fleshy vertical stem, called a rhizome, from which the roots, leaves, flowers, and stolons develop. The rhizome floats an inch beneath the water surface where it is protected by the water and by juvenile leaves folded tightly around it. This

insulation gives it remarkable hardiness. Frost may kill the plant's outer leaves, but unless the waterway freezes (an unlikely occurrence in tropical and subtropical habitats), the rhizome remains viable and responds to returning warmth with new roots, leaves, flowers, and stolons. In the cool waters of the San Joaquin delta near San Francisco, the hyacinth survives throughout the winter as a result of the rhizome's insulation. The leaves also protect the rhizome from herbicides—except in heavy doses. When the plants are thrown onto the bank of a river, as they often are, the sheath of leaves again shields the rhizome from desiccation. Plants at the

bottom of a heap can survive for up to three weeks.

Unlike most freshwater plants, the water hyacinth can tolerate salt water for brief periods. It has been known to float out to sea on the current of one river, travel along the coast, and move inland up a neighboring river. Over a period of days in a salty environment the rhizome remains protected and survives.

Even if a waterway dries up, the adaptable hyacinth can handle the change. When receding waters deposit it on the bottom mud, its roots penetrate the wet earth and take hold. The plant then shrinks and becomes a wizened caricature of its former self

with petioles as short as half an inch instead of the thirty-six inches often reached in the aquatic form. Moreover, the process is reversible; when the water returns, the plant separates from its earthbound roots and floats to the surface to renew aquatic life.

If a water hyacinth is sliced up, many of the individual pieces are able to reproduce. In one study, stolons, cut from a plant and placed in water, sprouted and generated new plants in less than two months. When split lengthwise, each half of the stolon also reproduced. If a split half was subsequently cut transversely, each end developed buds and sprouted as before.



Productivity is another characteristic of the water hyacinth. Its manufacture of solid vegetable matter appears to be more efficient than that of most plants. Indeed, some botanists have speculated that the water hyacinth may be the most productive plant on earth. In 1963 a British limnologist estimated that one acre of water hyacinth can produce up to sixty tons of dry organic matter annually. Since that time at least four other researchers have actually measured such amounts and have remarked in the literature on the awesomeness of the water hyacinth's pro-

The water hyacinth's growth can

literally be seen; a noticeable elongation of the leaves and stolons is visible from hour to hour. This comes about because with each part of solid laid down, the plant incorporates up to nineteen parts of water. The huge volumes of vegetation created in this manner are about 95 percent liquid. This ratio of water to vegetable matter largely accounts for the enormous expansion of hyacinth greenery across a waterway.

In competing with humans for the use of available water, the hyacinth often wreaks havoc. Its weight and volume can make a river impassable to boats. It piles up against abutments in masses that have pushed over

bridges. Colonies of hyacinth, driven by wind and currents, can knock a ship off course. The plant looks innocuous enough, but caught on the side of a moving boat, it can be taken to new bodies of water. In this way, within two years the hyacinth hitchhiked a thousand miles upstream on small boats and paddle steamers plying the Congo and Nile rivers. It now grows prodigiously in upstream swamps and backwaters, and breakaway colonies spew continually down great lengths of each river.

In Kota Bharu Province, on the Malay Peninsula, rafts of hyacinth that caught on obstructions built up to such proportions that they blocked a river in 1957. A tropical storm then caused the river to overflow its banks and flood the province.

The Panama Canal Company maintains an expensive dragline to pull hyacinth out of the Chagres River at the point where it flows into the Canal. Were it not for this and spraying with herbicides, hyacinth could make the Canal impassable to shipping within three years.

The competition between hyacinth and humans is most devastating, however, in irrigation projects. In India and other countries in desperate need of food, irrigation canals, drainage ditches, and pumps often become clogged with hyacinth. The flow of water is then reduced to a dribble that makes a mockery of expensive engineering schemes. Lured to the harsh, dry land by the promise of water, peasant farmers may find themselves facing economic ruin and starvation when their crops shrivel and die.

The hyacinth is also a problem in flooded rice paddies. It blocks out the sunlight, inhibiting the growth of the rice seedlings beneath the water. And those seedlings that do grow cannot push up through the sheer tonnage of hyacinth on the water's surface.

Man's development of waterways has also brought him into competition with the water hyacinth. In swiftly flowing rivers, the plants are swept away, but a dam creates large areas



Those who cannot walk on the water in Sri Lanka, can do the next best thing—walk on the water hyacinth.

of sluggish water that foster hyacinth expansion and provide the plant with living space. An estimated twelve square miles of hyacinth grew in the Brokopondo Reservoir in Surinam (formerly Dutch Guiana) during the two years following the dam's completion in 1962. Egypt's famous Aswan Dam is severely infested, as are the Jebel Aulia Dam in Sudan, the Boma Dam in Zaire, and the Apanás Dam in Nicaragua.

Humans are not the only animals to suffer from incursions of the hyacinth. Fish find shade, shelter, and food among the roots of small patches of the plant, but when colonies grow large enough to blanket the entire surface of the water, the effect is lethal. Life-sustaining oxygen can no longer pass freely from the atmosphere to the water. In addition, massive leaf debris sinks to the bottom and decays, further decreasing the water's oxygen supply. As a result, many fish die and only the hardiest species survive. Eventually, they too succumb to the oxygen deficiency, and the eutrophic water is left almost lifeless.

Other aquatic organisms are also affected by the presence of the plant. Waterfowl cannot inhabit ponds and streams covered by hyacinth, but mosquitoes find such abodes ideal. Sheltered from predators by the hyacinth roots and leaves, the insects thrive in the few square inches of stagnant water between the plants. The vectors of malaria, yellow fever, river blindness, and encephalitis flourish in these surroundings. Furthermore, snails, which play a crucial role in the life cycle of blood and liver flukes (varieties of parasitic worms), shelter, multiply, and find sustenance among the hyacinth roots. Debilitating diseases such as schistosomiasis and fascioliasis result and are spread as the mobile water hyacinth carries the snails to new locations. This process is now occurring on the eastern branch of the Nile River in the delta region near Alexandria. Until 1967 the area was swept by annual floods and water hyacinth was only a minor nuisance, but with the new High Dam at Aswan, the hyacinth is no longer flushed out to sea. Consequently, the plant has expanded with its usual vigor and there has been a corresponding increase in the incidence of schistosomiasis.

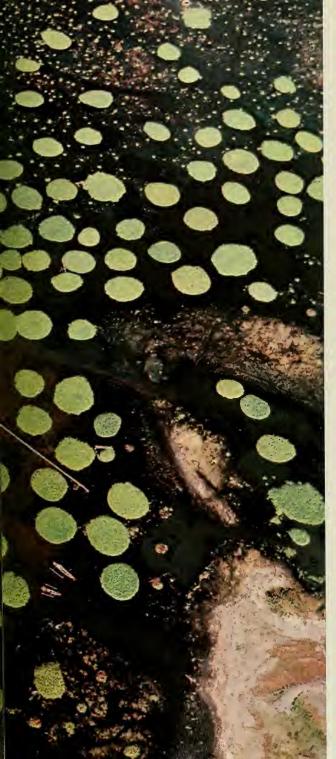
In the Philippines, water hyacinth is deliberately planted in circular patches that are used as fish traps.

Small wonder the water hyacinth is hated and disowned in many countries. Its colloquial names attest to the bitterness with which it is regarded. It is called the blue devil (in Bengal), the Bengal terror (elsewhere in India), and the Florida devil (in South Africa, where the plant is commonly supposed to have come from the Sunshine State). In Bangladesh it is known as the German weed because it became prevalent during World War I, and even today some think that its introduction to the subcontinent was a military inspiration. In Sri Lanka (formerly Ceylon), the hyacinth is called Japanese trouble in the belief that the British planted it during World War II to induce the expected Japanese invasion forces to land their aircraft on its flat green surfaces and thus come to a soggy end.

Since warm water fosters the growth and spread of water hyacinth, tropical and subtropical regions are the hardest hit. But in northern California, Japan, New Zealand, southern Australia, and Argentina, the plant is showing that it can survive equally well in temperate waters.

Despite its known record as a pest, the water hyacinth is still sold in several countries, including the United States where it is a favorite of tropical fish enthusiasts. Unfortunately, man has only imperfect weapons with which to battle this superplant. Despite every effort, the water hyacinth persists to this day in all the regions it has ever invaded. It has never been eradicated anywhere. All the control methods used have proved unsatisfactory in some respect. Herbicides that kill hyacinth are available, but they have several drawbacks: they are suspected of adversely affecting aquatic animal life; they are expensive and difficult to apply, especially in remote areas; in agriculturally developed areas, their drifting spray can destroy neighboring crops; and frequently, they are less than wholly effective. For example, the government of Belgian Congo undertook a \$1.5 million hya-





cinth eradication program in 1957. Masses of hyacinth at that time concealed ship channels and covered navigation buoys on the Congo River, imperiling vessels carrying copper and uranium ore to Europe and North America. Tributaries of the Congo were also covered, forcing the abandonment of small villages whose survival depended on the river. For one year boats traveled up and down the Congo, spraying the hyacinth with the herbicide 2,4-D. There was a temporary respite, but the effects did not last; one year after the program ended, the tide of hyacinth flowing down the river was estimated at 3,000 tons per day.

Many animal organisms are predators, pathogens, or parasites of the water hyacinth. Although they are not yet widely used, some of these have demonstrated a potential for restraining the plant. The weevil Neochatina eichhorniae, which feeds voraciously on water hyacinth but does not consume other plants, has been collected from plants growing in Argentina. The U.S. Department of Agriculture has already released the weevil in Florida, but although it is hurting the plant, it alone cannot eradicate or control extensive hyacinth outbreaks. In Puerto Rico the herbivorous water snail Marissa cornuarietis has been field tested as a water hyacinth predator. It, too, damages the plant, but like the weevil, the snail by itself cannot contain the hyacinth's growth and spread. Manatees, the sea cows of tropical waters, also hold promise, even though the hyacinth is not their favorite food. An international laboratory for manatee research, now being established in Guyana, aims to learn the secrets of manatee reproduction and husbandry so that these endangered mammals can be saved from extinction and put to use controlling aquatic weeds. Other organisms tested for hyacinth control include fishes, mites, viruses, bacteria, and turtles.

By focusing on killing the water hyacinth, we may be overlooking the plant's potential benefits. This efficient solar energy trap and source of productivity could perhaps be harnessed to the advantage of mankind. That idea, in fact, dates back to the earliest days of the hyacinth explosion, about one hundred years ago. But the discovery in the mid-1940s of the herbicidal action of 2,4-D came at a time when such wonder substances as penicillin, sulfanilamide, and DDT were regarded as panaceas. Like them, 2,4-D was considered a compound that would obliterate the problem; utilizing the water hyacinth was, accordingly, scrapped, at least in our part of the world.

Today the idea is resurfacing. A decade of research has made it clear that only one characteristic is holding back the widespread use of the plant: its 95 percent water content. One ton of hyacinth yields only 100 pounds of solid; water makes up the remaining 1,900 pounds. This is too much liquid to enable the plant to be handled economically. But mechanisms have recently been devised for pressing the water out of the hyacinth right at the river's edge. Pressed hyacinth contains about the same amount of moisture as the grasses grazed by sheep and cattle. It has adequate protein, fat, fiber, and minerals for fodder and it promotes normal weight gains. Detailed testing at the University of Florida has failed to detect toxic materials or untoward pesticide levels. Pressed hyacinth has already been made into silage, hay, and pelletized feed on an experimental basis. A Florida company manufactures sundried hyacinth into "peat" pots and potting soil. It has been tried, with good results, on thousands of tomato seedlings.

A new and provocative turn in our appreciation of the water hyacinth is now occurring. It appears that the plant offers one of the few possibilities for purifying polluted waterways. Terrestrial plants get their nutrients from minerals dissolved in the moisture of the soil; the hyacinth gets them from minerals dissolved in the water on which it floats. The principal plant nutrients are nitrates, phosphates, and potassium, which are thus the major ingredients of fertilizers. When these substances enter the water as agricultural runoff, sewage, industrial effluent, or pesticides, they are regarded as pollutants and are considered to be beyond recovery. The hyacinth, however, traps and uses them in its metabolism.

When the hyacinth is systematically harvested so that successive crops continuously suck nutrients Manatees are the world's only totally aquatic herbivorous mammals. Their voracious appetite for plants has been made use of in Guyana to clear canals of water hyacinth and other aquatic weeds.

from the water, the plant becomes a natural pollution control. Researchers in five American laboratories have demonstrated the hyacinth's remarkable effectiveness and a NASA laboratory in Mississippi is starting a large-scale hyacinth sewage filtration facility that will treat sewage from the city of Bay Saint Louis. The hyacinth will be harvested, fed into tanks, and fermented to methane (natural gas) to be used as fuel, while the rich, sludgy residue will be made into fertilizer.

In other parts of the world, man has long capitalized on the presence of water hyacinth. Fishermen in the Philippines and Bangladesh push bamboo poles into river bottoms to form circles ten feet in diameter. Within these circles, they plant water hyacinths. The floating green mats that result provide shade and shelter for much aquatic life. A net judiciously laid on the river bottom then captures the fish that congregate below the circular blooms.

Peasant farmers in Bangladesh and Burma also take advantage of the hyacinth. They create floating vegetable gardens by heaping fertile bottom muck on top of densely packed stands of hyacinth and reeds. Seedlings planted in these patches find ample nutrients and plenty of moisture. Eggplant, cabbage, cauliflower, cucumbers, peas, and beans cultivated in this manner grow luxuriantly.

Although the water hyacinth can be a pest, it has good qualities as well. High yield and rapid growth are generally deemed desirable. The hyacinth, which grows on water, rather than on overtaxed land, does not require irrigation, fertilizer, or seeds. Grown and harvested under supervision, it will absorb pollutants from our befouled waterways. Perhaps one day we will harness this prolific plant and thereby transform today's superpest into tomorrow's supercrop.





Alfred Moon's Farm

A chronicle of one man's life on the land, of his neighbors, and of an evolving New England landscape Alfred Moon was an easygoing kind of man, a very pleasant man. Nothing bothered him so long as he had cider enough and vegetables and groceries to keep him along. He was quite friendly, Alfred was. I don't hink he had an enemy in the world. He was a square-built man, rugged

looking, and I heard tell that when he was a young man, he'd take a 32-gallon barrel of cider, take it up by the chimes and drink out of the bung. Now it takes some power to do that! I don't know what a barrel would weigh, but I should say about 300 pounds.



by Richard F. Olivo and Henry W. Art Based on conversations with Arthur E. Rosenburg

Alfred was the type of man who never cut his hay till way, way late. Never cut it early. He'd wait till round into August sometime before he'd begin haying. Loose hay, in those days it wasn't baled or anything. Now of course, Alfred had to make his cider in the season, the fall

of the year. He just had to, because his apples wouldn't keep, you know, and the cider mills would be closed. But he always did his haying late. He was that type person.

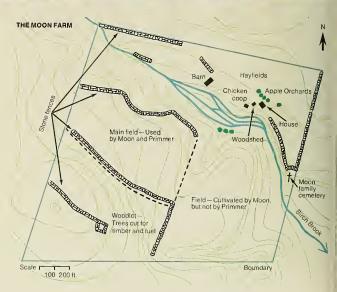
Alfred Moon was a farmer who lived an eighteenth-century life in the

twentieth century. His small, isolated farm was situated in Williamstown, Massachusetts, in the foothills of the Taconic Mountains. Unlike commercial farmers, who sell their products and buy groceries and supplies with the receipts, subsistence farmers like Alfred Moon are dependent on their





Built in the 1850s of heavy, roughhewn timber, and covered with wide boards, the barn on the Moon farm is still standing. A contour map of the farm shows all human additions to the land, including cultivated fields. Aerial views of the main field (far right) give a glimpse of forest succession. Still under cultivation in 1935 (the lighter patch indicates a freshly plowed area), the field was abandoned in the 1950s. By 1970, it had grown in with birch and various shrub species.



own land for food, fuel, and lumber. To buy any other essentials, Alfred Moon used the money he got from the small quantity of cider he sold.

A few of the older people in Williamstown still remember Alfred Moon. One of them is Art Rosenburg, who as a young man worked on a neighboring farm. Now 85, Art Rosenburg is still an active dairy farmer. This story is told in his words.

The Moon farm was, as I recall, sixty acres more or less. It was in the Moon family two generations or three. When Alfred's uncle died, then Alfred went there to run the farm and married the aunt. I should put that about 1875, in that neighborhood.

Alfred got his living off the farm, but he never gained too much wealth, because he depended upon the cider he sold. But he raised quite a lot of his own living there, like his potatoes, his beans, corn (husking corn, you know, for the hens). He didn't have to buy too much. He'd go down to the village here in the fall of the year and he'd put on a couple of bags of meal, something like that, and that was it. At one time, he kept a few sheep, but then he got rid of those. When he wound up, he had seven head of cattle. They was small stock, and of course he got his living that way: fat a calf, you know, butcher a calf in the fall of the year, or maybe a steer.

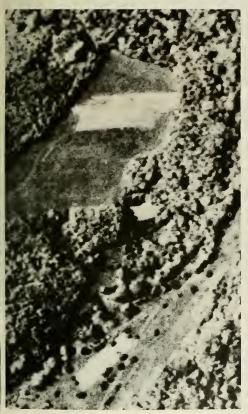
He'd raise enough hay for his heifers and cows and horses. He'd mow it down with a pair of horses. They wasn't big horses, they was small. Then he'd hitch one horse on this rake, single horse, see, and that rake would scoop the hay together and leave it in a windrow. And then he'd take a fork and pitch it onto a

wagon and draw it into the barn, loose.

And he trapped a little. He kept some furs. Now I know, you boys probably never caught a fox, but it is quite a trick to catch a fox. Most old trappers used to set traps in a spring, under the water, where the foxes go to drink. But Alfred had a better way. When he kept his sheep, one died one winter, and these foxes would come and feed on the sheep. Well, the sheep has this long wool on, you know, and Alfred would put the trap under the wool. Now wool, when it's in the raw stage, it's not only got a little scent to it, but it's a little greasy too. And he got several foxes that way one winter.

Yes, he raised his own pork, his own meat, and his own vegetables. He kind of went along as his ancestors had done.

Please turn to page 80





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Alfred Moon's ancestors were not the first to own the farm. John Smedley, an early Williamstown settler, cleared the land in the 1770s. The farm was purchased by Emery Chamberlin in 1824, at about the same time that farming was reaching its peak in Williamstown. A year later, in 1825, the opening of the Eric Canal marked the beginning of a prolonged migration of farmers from the stony New England hills to the more fertile plains of the Midwest.

In fact, the history of farming in Williamstown reflects the farming pattern of New England as a whole. When John Smedley first cleared his land, only about 2 percent of Williamstown's thirty thousand acres were cleared of forests. By 1800, after a period of rapid growth, more than 65 percent of the town had been turned into open land. Thirty years later, at the peak of farming, 75 percent of the land was open; farms ex-

tended throughout the valley and even up to the crests of the Taconic Mountains. But as agricultural competition from the Midwest forced a shift from subsistence farming to larger, specialized commercial farms, and as manufacturing rose in New England, farming declined. By 1850 farm abandonment had reduced the open land in Williamstown to about 50 percent. This level of farming remained stable almost until World War II, at which time a modern phase of farmland abandonment reduced open land to 24 percent by 1952 and to less than 14 percent today.

Thus, by the late 1850s, when Daniel Moon, Alfred's father, bought the farm, it had already become an anachronism; it was a small, hillside subsistence farm in an era when many small farms had been abandoned or consolidated into larger sheep and dairy farms.

By 1862 the farm had been sold to Alfred's uncle, Andrew Jackson



Alex Carro

Moon, who was listed as the sole owner when the farm was mortgaged in that year for \$227. Twelve years later, in 1874, Andrew Jackson Moon died of consumption. The farm was left to his wife, Adelia, and their six-year-old son, Benjamin Franklin Moon. By the time the 1880 Census of Agriculture was taken, Alfred Moon was the farmer of record. At some time between his twentieth and twenty-sixth year, Alfred Moon had taken over the farm and had married

Mrs. Moon was a tall, lean lady, I should say, maybe five foot eight, seven or eight, along in there. Very quiet, she never said too much. Very pleasant. I've seen her come down from the farm once or twice, but she never got out to go down to the village too often. I don't think even Alfred would average going to town more than once a month. He would drive the buggy and the horse, and he'd always have the kerosene can with



him; of course, that'd keep a lamp going quite a while. I think he got his mail through the post office when he was downtown, 'cause he never had a mailbox down on the main road. And I don't think Alfred Moon ever had a daily newspaper in his whole life. He was pretty isolated. You take the winter of '88, there was deep snow, he couldn't have got out of there for two months, the snow was so deep till it settled.

The original barn and house, built by the Moons in the 1850s, are still standing. Parts of the floors and walls have broken through, but the heavy posts and beams still meet as solidly at their mortise and tenon joints as they did a century ago. Wooden pegs, rough timbers, and round log rafters are the materials of the house and barn. An addition to the front of the barn dates from the early 1900s.

The barn was small, not too much room in there, because on good days Alfred would let the stock right out, even in the wintertime they was out, unless it was stormy days that kept

That barn, the main part, is put up with pins. That's been there a good many years then, been put in with the pins, because they don't do that no more-haven't in a long, long time. I imagine it was Alfred's uncles that built the barn. There was quite a lot of Moons living at that time; they might have chipped in and got together and helped build the barn. You see, they'd get out these logs and use a broadax to square them. They'd score a log and then they'd come back through and rip the piece right off and it'd be fairly square on that side. Then they'd turn it over and make chippings off the other sides. And after it was squared, they'd measure. Now you'd be surprised at these old fellows that didn't have the education they should have, but they'd drill those holes when those beams was down on the ground, and they'd get their pegs ready. Then they'd have a barn lifting, have the neighbors come in to help put these up, and I'll be damned if they didn't all come right to. They'd peg them right together.

The house was probably built about 1850, 1860, sometime in there.

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But it still is in pretty good shape. Those buildings generally stand up pretty good. They built the framework, and then it was very easy to side it up, because your plank went up and down. And they either used clapboards afterwards or it was double boarded—they'd put two sets of boards on, so the wind wouldn't blow in. I imagine that was the way it was built.

With all these old buildings the neighbors would all help build them, because one man couldn't put up these big beams—some of them are huge, jeez! You take a beam 14 by 14 and 18 or 20 foot long, there was quite a lot of heft there. You've got to have quite a lot of beef to put it in place.

Now I don't think Alfred ever done much repairing on the house or anything. I think the roof was in good shape and that kept out the water, and I don't think he had to. He had the fire in the house that kept the dampness out. In those olden days, you see, your shingles lasted so much longer than they do today.

And that house has quite a cellar in it. That's where he kept his cider and his apples, potatoes, and vegetables. Of course, he'd have a pretty good garden, like all the rest of the farmers. They'd raise carrots, turnips, beets, squash, and potatoes for the winter. And they was stored in the cellar. There was no heat, you know, and they'd keep very good in these old cellars.

On the lower side of the house is Birch Brook, which in Alfred Moon's time was called Buxton Brook. It is a clear, shallow stream running over sand and rocks. Like many old farms, Alfred Moon's farm was built near a brook—its sole source of water. Above the house, and also across the brook, are the remains of apple orchards.

There used to be a lot of good apple trees in there. And years ago apple trees bore heavily 'cause you didn't have any bugs. They didn't have to spray either. Don't spray it at all and get wonderful fruit. Alfred used to put in, oh, about twenty-five barrels of cider. He'd go down to the cider mill somewheres handy, see. He had no right to sell the cider, but he took the right. There was a law you couldn't bootleg, but whiskey was scarce and high. There was a lot of those places years ago.



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Now as Alfred got a little older, he had this bad heart. He wasn't an oldlooking man at all, but he had this bad heart that came on to him. Then in the fall of '23 his stove gave out. We had one there at the farm. I think it was a Glenwood if I remember; kitchen stove, it was in good shape but had been used. I took the stove up and set it up for him. In exchange he wanted me to have a heifer, but I said, "Oh, no, we can forget that." And that's the way it stood.

And then that same winter Alfred was stricken with a heart attack. Dr. Nelson here in town, he went out to the Moon place and advised Alfred to get rid of the stock. He told him, "You're going to go down to the brook for a pail of water and you're going to tumble in and you won't get back." And that kind of scared Alfred.

So I went up and got the stock for Alfred and put them in Mr. Hopkins's sheep barn. Alfred had seven head at that time, four cows and three heifers. He also had two small horses, a little spare farm team. I sold them to a dealer for him. They didn't bring too much. The cattle, you know how they looked, they were small and thin. He took the whole bunch and I can't now remember what he gave for them at that time.

A short time after that, the Moons moved over to the Whitney farm. They couldn't stay at their own place any longer since the doctor couldn't get in there through the winter. And after that Alfred slipped fast. He died soon after that. I don't know who got his furniture. I think his brother Herb got the violin.

Mrs. Moon got along into years. Her eyes weren't too good and of course she didn't have glasses or anything. She was very quiet. Now even when she was over at Whitney's, you'd go in there and speak to her and she'd speak to you. And then she'd go a little in this rocking chair, just rocking. She lived a long life. She lived at Whitney's till she died, and she was a hundred, I think, a hundred and three years old when she died.

Benjamin Franklin Moon, Alfred's stepson and cousin, had died in 1896 of a shotgun wound, and there were no other children. Shortly before Alfred Moon's death in 1924. the farm was sold to Lowell Primmer for \$1,200. The sale marked the end of a century and a half of direct subsistence farming on this land. Lowell



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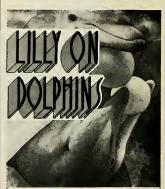
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Primmer was first a part-time farmer, then retired to the farm to live on his railroad pension. He abandoned a few of Moon's fields, but kept the main fields open. He left the farm in

At the time Lowell Primmer bought the farm, we was quite surprised. We knew he wanted it. But he came by one day and he told us, "I bought the Moon place." You see, he was an engineer on the Boston and Maine, and he didn't work on the farm full-time till he was retired from the railroad. And then as he retired he went into the wood business; he sold quite a lot of wood. And strawberries-he was a great strawberry man. Raised a lot of strawberries.

But after Lowell left the farm, it changed. As the years went by, it grew up, and the buildings depreciated. If you go up to that farm now, the growth that's come in, the meadows kept growing smaller. That upper meadow was much larger; it was quite a good field in there at one time. But it kept coming in, growing in. It made the field smaller each time. I talked with Lowell one time about it, and he was very, very sad

about it. He seemed to be upset that the farm went that way, grew up and went to waste.

There's been a lot of changes, yes, even since I've been up there. The wood, the mountain, the forestthere's some beautiful logs in there, let me tell you, they're beautiful, nice. Jeez, how a lumberman would like to get in there! They run right up there, you take off maybe three or four 12- to 14-foot logs from some of those trees. I was surprised. But you leave a place any length of time and not cut it over, and it grows up very fast. And then you can't cut it over.

The farm is being taken over by forest. The fields have grown over; shrubs hide the house and barn. The farm had never been mechanized, never had electricity or running water-a farm much like the thousands of small farms that once covered the New England hills. Because Alfred Moon's farm persisted into the mid-twentieth century, it has provided a modern glimpse of what has happened many times during the last century, as the New England forest recaptures the land.

In 1971 Alfred Moon's farm was

purchased by Williams College. It is now part of the Hopkins Memorial Forest, a research facility devoted to studies of man's effect on the landscape. These studies have shown that after farmland in this region is abandoned, various shrub species, along with gray birch and paper birch, invade the cultivated fields. Red maple colonizes the pastures; striped maple, black birch, and yellow birch fill in the understories of woodlots. Within 50 to 150 years, the birch and red maple forests are in turn displaced, usually by a forest dominated by red oak. Finally, the red oak forest is replaced by the climax forest for the region: sugar maple, American beech, hemlock, and yellow birch.

The sequence and duration of the various stages in the progression from fields and pastures to climax forest are strongly influenced by man's use of the land. Alfred Moon and other farmers like him had an effect on the landscape that will last for many years to come. But eventually, in enough time, the climax forest reappears. The land then is much as it was when it was covered by the primeval forest, before the first farmers arrived.

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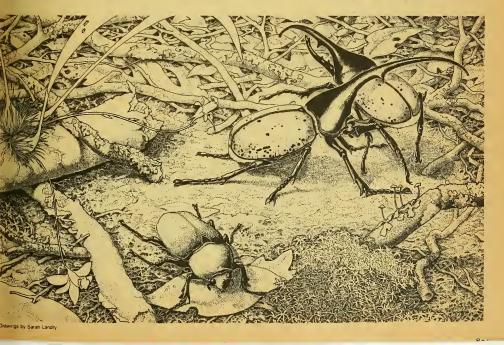
SOCIOBIOLOGY, by Edward O. Wilson. Belknap/Harvard University Press, \$20.00; 697 pp., illus.

It is highly probable that the only person qualified to review this book is the author himself. Who else could speak with such familiarity, self-assurance, and apparent authority about a series of topics that range without significant break from the structure of DNA to the current status of behavioral psychology and the sociological traditions of Durkheim, Weber, and Parsons? Certainly this reviewer cancot. I will therefore simply attempt to summarize the book's principal parts and make some surmises about what

its immediate reception and possible place in history may be.

In the first place, and most obviously and certainly, the book does us all an enormous service in bringing together (in one oddly shaped volume) most of the important things we think we know about the basic biology of animal behavior. Like other scientific knowledge, sociobiology has been growing at an exponential rate, but it started more recently and the exponent seems even larger than usual. As a result, recent increments, especially in knowledge of primate behavior, leave the breathless observer with the impression that things are happening in quantal jumps. It is indeed somewhat rare for a treatise,

which purports to cover the century or so since the Descent of Man, to have such a high proportion of references to papers published in the last five years. The bibliography covers sixty-four double column, 10- by 10inch pages; and it is a rare page that does not include one or more citations of papers published in 1973 or even 1974. Besides the obvious testimony to the industry and determination of the author, this says a lot about the dedication and efficiency of the publisher-to say nothing of his tolerance for last minute changes in proof. And while on the subject, the printing, the proofreading, and the reproduction of the many drawings, photographs, and diagrams are all excel-



lent. Whatever else it may or may not be, this 697-page work is a *tour de force* of collecting, winnowing, interpreting, speculating, and publishing.

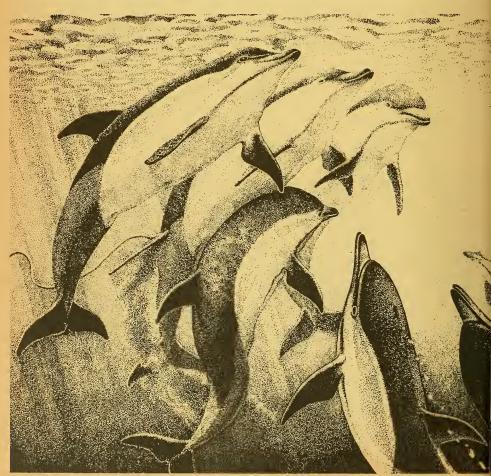
The first five chapters outline the basic principles of genetics and population biology. Although these include much of what would be found in any competent treatment of the same topics of comparable length (130 pages), we are immediately aware that something new is going on here. Far from being "sicklied o'er with the pale cast of thought" about separating fact from value, Wilson entitles his first chapter "The Morality of the Gene" and takes his first sentence from Camus, "The only serious philosophical question is suicide" (with which, incidentally, he does not agree). The survey ends with a longish chapter on "Group Selec-

tion and Altruism," which must contain just about all the available evidence for a biological explanation of virtue. It probably should be pointed out, however, that a nonbiologist could read the entire chapter without being warned that some crusty old theoreticians have never been able to agree that natural selection works on anything but individuals.

Part II gives us twelve chapters on "Social Mechanisms," beginning with "Group Size, Reproduction, and Time-Energy Budgets" and ending with a review of "Social Symbioses." All these strike the nonexpert reviewer as up to date, sophisticated, and wherever possible, admirably quantitative. The three chapters on communication seemed particularly fine for the way they brought the theoretical considerations set

forth by Shannon, Chomsky, Hock ett, and others into critical interrela tion with visual, aural, and odorif erous displays of animals trying to share their hopes, fears, and excite ments with their fellows.

Although, as hinted at above, Wil son clearly has his own biases and expectations, his explication of socia mechanisms is broadly conceived and executed. As such it amply sets the stage for Part III, which details in some 200 pages the various behav ioral adaptations of "The Social Spe cies" from colonial microorganism to man. The author has devoted mos of his career to the Harvard impera tive enunciated by William Morto: Wheeler (with biblical assistance) to "go to the ant . . . consider her ways and be wise." But he does not burde us here with his erudition regarding



invertebrates. The selections from his store of field observations and library studies are always apt, crisp and to the point, and no more voluminous than his citations from the rapidly growing literature on dolphins, elephants, wildebeests, and baboons, which he must know largely at second hand.

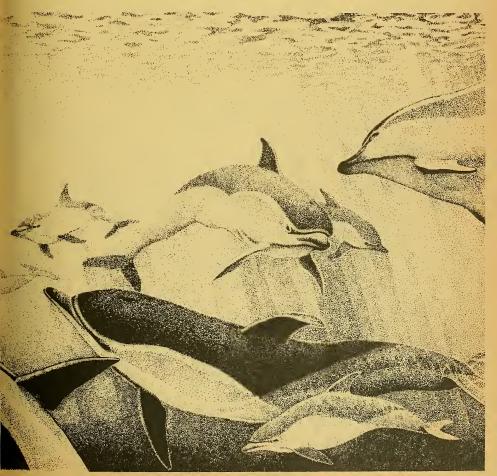
So there it is; as a carefully selected and synthesized compendium of what we know about the social behavior of animals, it stands alone—almost certainly a landmark, quite possibly a monumental one. But what about the other part that attracted our attention on the very first page—the intention to lay the groundwork for the study of futuran society in all its richness of fact and value? Perhaps this part of his purpose is stated most clearly where, after describing the "Modern

Synthesis" of taxonomy and ecology with neo-Darwinist theory, he continues, "It may not be too much to say that sociology and the other social sciences, as well as the humanities are the last branches of biology waiting to be included in the Modern Synthesis." Maybe so, but one wonders if this is the best way of luring disciples of these historic schools to read the book ushering in the new synthesis. Any pool player appreciates the "unwisdom" of calling one's shots in advance; so what are we to do with the flat statement that ethology and comparative psychology are both destined to be cannibalized by neurophysiology and sensory physiology from one end and sociobiology and behavioral ecology from the other?

As a onetime neurophysiologist, your present reviewer may look for-

ward to meeting his new friends, the sociobiologists, across this not entirely festive dinner table but he wonders a little about the relevant others.

But Wilson is undoubtedly right in observing that, in spite of their "great style and vigor," such attempts to derive man's higher social behavior from phylogenetic analysis as those made by Lorenz, Ardrey, Morris, Tiger, and Fox tended to be "inefficient and misleading" because they selected one plausible hypothesis or another based on a review of a small sample of animal species, then advocated the explanation to the limit. He then goes on to describe the "correct approach" as depending on a careful analysis of behaviors of many closely related primates and extrapolating only the most stabile or conservative

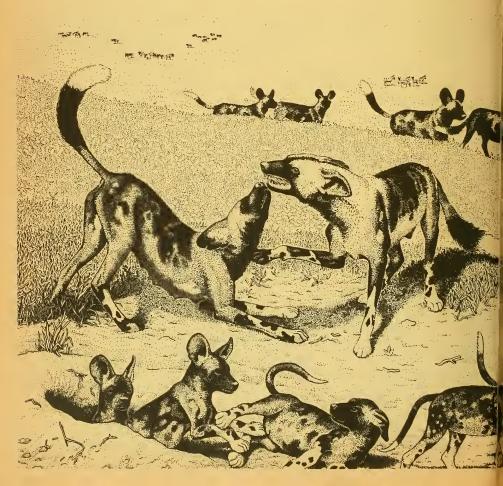


to man. Certainly the procedure is more cautious and probably more logical than that followed in the past by Ardrey, Morris, Tiger, and others. But after a long paragraph of discussion, it appears that Wilson himself is not entirely sure of just what we can learn about man by following the route he describes. Indeed, he confesses "that the comparative ethological approach does not in any way predict man's unique traits."

The trouble, of course, is that it is man's unique traits that we are interested in—especially his use of language, his invention of technologies, his passion to understand; above all, his penchant for developing his own social structures with their own rules regarding such peculiarly human notions as right and wrong, justice and mercy.

Fortunately for those of us who share his general commitment to biology as an explanatory, as well as a descriptive, science, Wilson's awareness of the uncertainties does not constrain him to a self-denying ordinance. On the contrary, he devotes the rest of his last chapter to an outline of the evolution of such human traits as "Barter and Reciprocal Altruism; Bonding, Sex, and Division of Labor (women's lib will surely have something to say here, as well as elsewhere in the book); Role Playing and Polyethism; Communication; Culture, Ritual, and Religion; Ethics"; and so on. In all this, cultural evolution is treated as being closely interwoven with biological evolution, rather than being sharply separated from it in the usual way. Here he gives us some figures to show that gene flow through populations and consequent biological evolution may not necessarily be so slow as to be completely overwhelmed by cultural developments, as we have usually been taught to believe

In the long run, this emphasis or continuing and current interaction between cultural constructs and biochemical genes may be Wilson's most enduring theoretical contribution. For the present, it is primarily provocative and one awaits with growing excitement the debates that are sure to follow. When one counts up the possible protagonists of the conventional wisdom in economics. sociology, psychology, and indeed in biology itself, who must be ever now aiming their arrows in his direction, we can only hope that he doe: not become the Saint Sebastian of so



biology. One of the arrows incientally may be fired at rather close inge by a young, energetic, and allady celebrated population genetiist who has even more interest in soial (and political) affairs than Wilson imself. In moments of excitement, has recently taken the position that han's central nervous system has volved so far toward infinite plascity as to transcend completely the emnants of genetic patterning that has to transcend down to us from former generations.

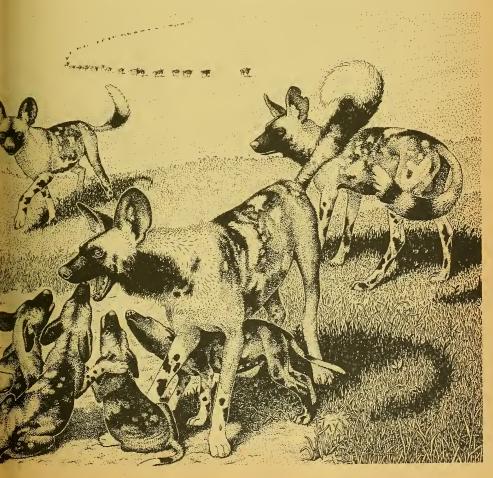
In general, Wilson seems amply repared to take care of himself in the nevitable debates. Indeed he is so elf-confident as to indulge himself in the least three highly controversial, if ot completely unsupported, speculations on quite a different level in the oncluding pages of his great work:

(1) Mankind will probably achieve an ecologically steady state by the end of the twenty-first century; (2) About the same time (he is less clear about the exact timing here), sociology will become reduced and resynthesized as neurobiology; and (3) Once "we have progressed enough to explain ourselves in these mechanistic terms . . . [we will face] the foreboding insight of Alfred Camus . . . 'in a universe divested of illusions and lights, man feels an alien, a stranger. His exile is without remedy since he is deprived of the memory of a lost home or the hope of a promised land." Although Bishop Wilberforce, Feodor Dostoyevsky, Matthew Arnold, and Henry Adams, among others, anticipated Camus, and Theodore Roszak and Jacques Ellul currently share the same insight, each

according to his own fashion, it seems an odd way to end a book so full of the excitement of curiosity, the joy of discovery, and the contentment of contemplation.

Indeed, is it really impossible that, following the very mechanisms proposed in this book, man would not evolve the sense of purpose and satisfaction, precisely in his loneliness, the unique ability to do the kind of things Wilson continues to do so well. As one thumbs through the possible scenarios, this seems like a natural selection.

Robert S. Morison was professor of biology and director of the Division of Biological Sciences at Cornell University. At present, he is visiting professor at Massachusetts Institute of Technology.



Celestial Events

by Thomas D. Nicholson

Sun and Moon The duration of daylight decreases from about 10 hours in mid-November to less than 9½ hours by mid-December. The earliest sunset of the year occurs on December 8. The latest sunsie, however, will not take place until early January. A waxing gibbous moon brightens the evening sky till well past midnight in mid-November. The moon becomes full on November 18, and observers in the eastern half of North America can see at least part of a total lunar eclipse as the full moon rises that night. Waning thereafter and rising later each night, the moon reaches last-quarter on November 26 and new moon on December 2. Appearing again as a crescent in the evening sky about the 5th or 6th, the moon reaches first-quarter phase on December 10 and becomes full on the 18th.

Stars and Planets Just south of the Square of Pegasus, high in the south southwest and brilliant among the dim stars of Pisces, you will find Jupiter. Well to its left, look for Mars in Taurus, brighter than, and not too distant from, Aldebaran, the bright star in the V-shaped cluster called the Hyades. You will see Orion rising just below Mars. To its right, arranged vertically above the horizon, are three objects almost identical in brightness. The lowest will be Saturn; the two above are Pollux and Castor, the twin stars in Gemini. By morning, Taurus, Orion, and Gemini will have shifted to the west. Jupiter will have set a few hours after midnight, but Mars and Saturn will remain to greet the dawn sky. Venus will be brilliant and high in the east.

November 15: Jupiter accompanies the moon across the sky tonight. November 18: A total lunar eclipse occurs early this evening, partially visible in central and eastern North America, where the moon will rise while the eclipse is in progress. Farther west, the eclipse ends before moonrise. The eclipse begins when the moon enters the earth's shadow at 3:39 P.M., EST. Total eclipse begins at 5:03 P.M. and ends at 5:44 P.M. The moon leaves the earth's shadow at 7:08 P.M. These EST times will be one hour earlier for each time zone to the west.

November 20-21: Mars is the bright object near the moon.

November 23: Saturn is near the moon tonight.

November 28: Mercury, in superior conjunction with the sun (beyond it in our sky), becomes an evening star.

November 29: Early this morning, you will see Venus quite close to the crescent moon in the dawn sky. Even closer to the moon is Spica, the bright star in Virgo. The moon is at perigee, nearest earth.

December 8: This is the day of the earliest sunset of the year. Mars on this date approaches closest to the earth during this cycle of its configurations. Its distance is about 53,566,000 miles.

December 10: Jupiter ends its retrograde motion and begins to drift easterly (to the left) below the stars of Pegasus.

December 11: The moon is at apogee, farthest from earth.

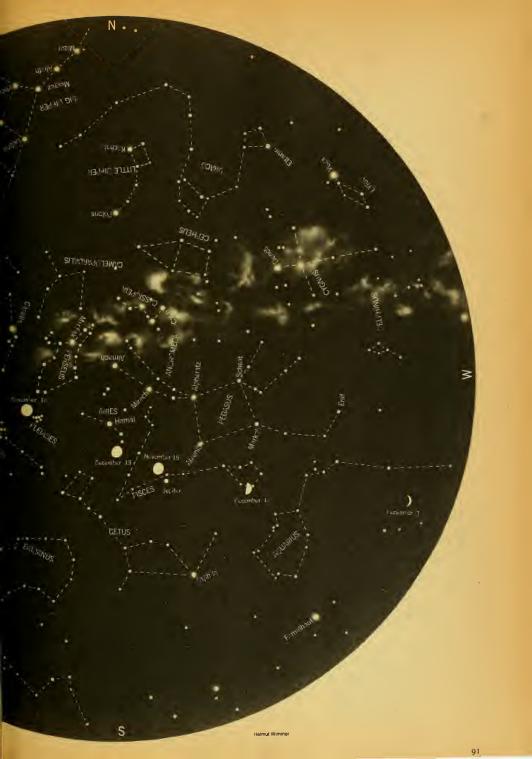
December 12: Jupiter is the bright object near the moon tonight, closest at about 8:00 p.m., EST.

December 13-15: The Geminid meteor shower can be seen after midnight on any of these dates, but is best on the 14th.

December 15: Mars is at opposition from the sun, rising at sunset, setting at sunrise: in the east at dusk; in the west at dawn.

★ Hold the Star Map so the compass direction you face is at the bottom, then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:20 P.M. on November 15; 9:20 P.M. on November 30; and 8:20 P.M. on December 15; but it can be used for about an hour before and after those times.





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The Red Rectangle

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An unusual nebula called the "red ectangle" has been found around a louble star known as ADS 4954. Vebulae are clouds of interstellar gas r dust, and several thousand have een identified in our Milky Way galxy. Only a few, however, such as he Orion Nebula, are bright enough be visible to the naked eye, the rest re either telescopic objects or dark ebulae that do not shine but are recgnizable on sky photographs as lack spots in crowded star fields. Nost nebulae are soft-edged and eiher round or very irregularly shaped. he red rectangle, by contrast, has elatively crisp, linear edges and, espite its name, is shaped like an ourglass. It is also an intense source f infrared radiation. (Its not-quiteccurate designation comes from a urvey photograph taken in the 1950s n which it appears to be rectanular.) About 1,100 light-years from arth, near the southern border of the onstellation Monoceros, "the Uniorn," and visibly dim even though t is more than two million times arger than the diameter of our sun, he red rectangle is of interest to asronomers because infrared sources re associated with the poorly undertood interstellar and circumstellar lust clouds of our galaxy. The object, ccordingly, had no less than fifteen elescopes trained on it last year at najor observatories from Canada to Chile.

Attached to the telescopes were intruments representative of the entire tray of investigative tools available o contemporary celestial researchres. They ranged from the simple shotographic camera and conventional spectrographs and photometers o electronic image-intensifying detices, infrared sensors cooled with dequid helium, and even a "dual chanel rotating half-wave plate polarmeter coupled to a NOVA computer," for measuring the polarization of light waves. From the data gathered with this complex equipment, it appears possible that the red rectangle may be a distant solar system in the process of forming around ADS 4954, its own pair of suns.

The salient findings leading to that possibility can be briefly summarized. Photographs made with the 4-meter (159-inch) Mayall telescope at Kitt Peak National Observatory near Sells, Arizona, showed that the "rectangle" actually has an hourglass shape, with the binary star ADS 4954 at its waist. The two lobes of the hourglass appear to be shining by reflected light from the binary. By contrast, the infrared radiation does not come from the whole object but from a small cloud of dust at the waist that is heated by the twin stars. Although ADS 4954 was discovered in 1915, one member of the pair has not been sighted since 1962. Nevertheless, the unseen star is believed to be present and quite luminous, although temporarily obscured from view on earth by a dense fragment of the dust cloud. We infer this because the one star that we do see now could not heat the dust cloud sufficiently for it to give off the measured amount of infrared light.

Based on its shape, the red rectangle appears to be a member of a small and not fully understood class of celestial objects known technically as "cometary nebulae." This class is so rare that it is omitted from three of the leading English-language books on nebulae. The name derives from the resemblance of some of these objects to a comet with a star at its head. Being shaped like an hourglass, the red rectangle is classified as a biconical cometary nebula, suggesting two wide, fan-tailed comets, head to head.

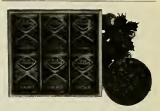
The nature of these rare nebulae has been debated by astronomers for several decades. The principal argument concerns the relationship of the stars to the nebulae: were these young stars formed by condensation from the material of the nebulae or, on the contrary, were the nebulae produced

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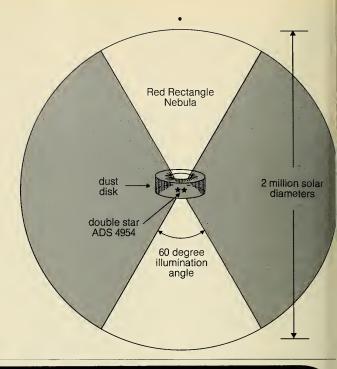
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Cross Section Through the Red Rectangle

It is assumed that the nebula is actually spherical, although it looks like an hourglass to us. Infrared radiation comes from the dust disk. The binary star ADS 4954 is in the hole at the center of the disk. Light given off by the twin stars is filtered by thin dust in the hole and looks red when reflected by the nebula. The size of the hole determines the illumination angle of the nebula-about 60 degrees. The part of the nebula shown here in light gray cannot be seen from earth because the binary star does not illuminate it. (The nebula is so much larger than the dust disk and the binary star that they have been exaggerated in this diagram.)



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y the expulsion of matter from the tars? The nature of the nebular glow as also been questioned. Many asronomers believe that the light omes from the stars at the "comeary" head and is reflected by dust articles in the nebulae. Others, notng that the spectrum of the nebular ght is sometimes different from that f the nebula's star, have suggested nat the light is produced, at least in art, by some as yet unknown process the nebular gas itself. Also of conern has been the wide range in the ppearance of cometary nebulae: ome are arc shaped; others are decribed as resembling commas; some ave the classical cometary, or fan, nape; and still others are biconical or ourglass shaped, like the red rectanle. Could all of these shapes be vari-

tions of the same kind of object? One proposal by Martin Cohen, an frared astronomer at the University f California in Berkeley, suggests at the variety of shapes may be due changes in perspective. For exnple, when a nebula with the shape an hourglass is looked at frontally, straight on, it is seen as a genuine ourglass like the red rectangle. As ne end is tilted toward the viewer, owever, the nearer lobe will be ainly visible and appear to increase size, while the farther one will be duced in apparent size or possibly completely obscured from view. nder such viewing conditions, the earer lobe will be seen as a simple, n-shaped cometary nebula. If one art of a cometary nebula is brighter an the rest (possibly because of a cally enhanced concentration of reecting matter), the comma shape ay result. Finally, if the hourglass seen end-on, it will have a circular oss section, and the brightest part the circle will appear as an arcaped nebula.

The dense concentration of dust in e infrared source at the waist of the d rectangle may explain how its ourglass shape arises. It is theorized at the dust is concentrated in a thick sk with a hole at its center, and that e double star at the waist is inside e hole. It is further supposed that a und cloud of gas and dust less dense an the disk entirely surrounds it. ne starlight escapes primarily rough the top and bottom of the ele. Its restricted beams thus illuinate only two conical regions of e larger, thinner enveloping cloud, d thereby produce the hourglass ect. If the hole the starlight shines

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The red rectangle, as shown in a 15-minute time exposure through a red filter made with the 4-meter Mayall telescope at Kitt Peak National Observatory. The spokes emanating from the object represent a genuine part of this nebula and are not optical effects in the telescope.

through is not perfectly clean but contains a modest amount of dust, the light's spectrum could be sufficiently modified prior to reflection in the conical regions to account for the observed difference between the stellar and nebular spectra. It was that discrepancy that led astrophysicists to propose that the light of a cometary nebula is not always the reflected light of its associated star.

If the binary star ADS 4954 has indeed condensed from the surrounding nebula, then the dust disk at the waist of the red rectangle has special significance. According to modern theories of the origin of the planets in our solar system, they were formed by the condensation of gas and dust particles in just such a disk, which is thought to have surrounded our own star-the sun-during its formative stage. Thus, by analogy with our own solar system, it is possible that ADS 4954 is a newly formed binary star around which a new solar system may be coming into existence.

But other ideas have also been put forward to explain the red rectangle. For example, it has been noted that its hourglass shape resembles the pattern predicted by some astrophysicists for the flow of condensing matter in a magnetic field. In that case, it would be unnecessary to invoke the

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oncept of the lobes of the hourglass hining by reflected light from a star na hole in a dust disk. Instead, magnetic effects alone would produce the lourglass shape. However, no evidence has yet been found for a magnetic field in the red rectangle. It has lso been suggested that rotation of the entire nebula around its own long xis could produce the hourglass hape, but again there is no evidence or such spinning.

The leading Soviet investigator of ometary nebulae has proposed that uch objects are generated when the xpanding region of interstellar lasma, or hot material, produced by adiation from a young, hot star enounters a cool, dense cloud in space. according to this theory, the cool gas ill then stream away from the hot tar, forming a fan-shaped region ith a new condensing star at the verex of the fan. While this theory might ccount for single cones, it seems unuited to explaining biconical objects uch as the red rectangle. The longanding idea that cometary nebulae ay represent material ejected from neir associated stars, rather than that ne stars form from their associated ebulae, cannot be definitely exluded. But, in that case, one woners why the dust in the red rectangle concentrated in a disk, whereas iost of the nebula has been ejected other directions.

On balance, it seems most likely to e that the red rectangle is an interellar cloud that has recently given irth to twins-the binary star ADS 954. Planets of this star may form the future or be in the process f forming now in the dense, disknaped region of dust that produces ie infrared radiation at the nebula's aist. In addition, the lobes of the ourglass may be analogous to an normous cold region in our own olar system outside the orbit of luto, far from the sun, where comets ich as Kohoutek are believed to ive formed. It is therefore possible at the early stages of both planetary id cometary creation are now under ay inside the red rectangle. If so, is object, as well as others in the nall, neglected class of cometary bulae, is surely worthy of further vestigation.

ephen P. Maran is an astronomer id researcher who studies stars, bulae, and comets at NASA's oddard Space Flight Center in reenbelt, Maryland.



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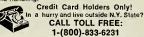
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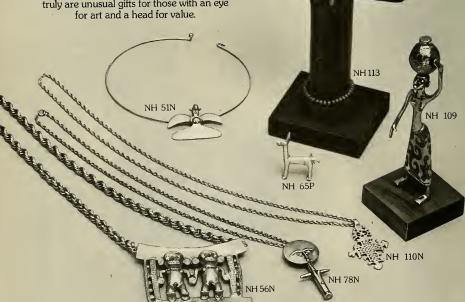
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Additional Reading

Malnutrition (p. 27)

Interactions of Nutrition and Infection y N. B. Scrimshaw et al. (Geneva: Vorld Health Organization, 1968) is a ood review of disparate studies on umans and other animals that examines he importance of these two factors to vorld health. A book to be published later nis year, L. J. Mata's The Children of Santa Marie Cauque gives a detailed picare of the human ecology of the Guatenalan village referred to in this issue's rticle. The April and May, 1975, issues f the American Journal of Diseases of Children were entirely devoted to more nan forty papers from a recent sympoium on the latent effects of intrauterine nalnutrition and infection on the growth nd development of children. Alan lerg's The Nutrition Factor: Its Role in lational Development (Washington: The rookings Institute, 1973, \$3.50) moves utrition beyond its clinical and laboraory confines into the realm of economic evelopment, treating it as an important eterminant of human and national perormance. From this perspective, Berg ffers a far-ranging exposition of the omplex problem of malnutrition in deeloping countries. The journal Science evoted its entire issue of May 9, 1975 ol. 188, pp. 501-653), to the world ood situation, providing 24 up-to-date view articles grouped under such topics "Food: Economics, Politics and Soal Structure; Nutrition; Agricultural esearch"; and so on.

rimate Motherhood (p. 48)

An article by R. D. Martin, "Ascent the Primates," in last March's Natural istory, provides a useful basis for the olutionary concepts that he expands oon in the present article. Allison Jolly's ooks on primate behavior may also be onsulted (Lemur Behavior: A Madagasir Field Study, Chicago: University of hicago Press, 1966, and The Evolution Primate Behavior, New York: Macillan, 1972). Any of a number of recent urnal articles on the subject, such as Survival, Mating and Rearing Stratees in the Evolution of Primate Social ructure" by J. D. Goss-Custard et al. olia Primatologica, 1972, vol. 17, pp. 19) and C. H. Southwick and M. F. ddiqi's "Contrasts in Primate Social chavior" (BioScience, 1974, vol. 24, . 398-406), will also help the reader



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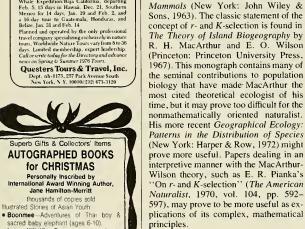
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Mantids (p. 58)

Mantids are dealt with in most popular accounts of insect behavior, such as E. W. Teale's The Strange Lives of Familiar Insects (New York: Apollo Editions, 1968, \$2.25). Scholarly, yet highly readable accounts of scientific investigations of the complexities of mantid behavior may be found in the 2nd edition of K. D. Roeder's Nerve Cells and Insect Behavior (Cambridge: Harvard University Press, 1967) and in "Episodes in Insect Brains," recently published in American Scientist (1970, vol. 58, pp. 378-389). M. Edwards's "Defensive Behavior in Ghanian Praying Mantids" (Zoological Journal of the Linnean Society, 1972, vol. 51, pp. 1-32), an excellent example of the type of descriptive field studies being done, is illustrated with a fine series of color photographs.

gain an evolutionary perspective. De-

scriptions of maternal behavior may be

found in F. Bourlière's The Natural His-

tory of Mammals (New York: Alfred A. Knopf, 1954) and in H. L. Rheingold's edited volume Maternal Behavior in

Water Hyacinth (p. 64)

In a recent article entitled "Aquatic Weeds" (Science, 1969, vol. 166, pp. 699-709), L. G. Holm et al. present a comprehensive review of a sparse and far-flung body of literature on undesirable aquatic vegetation. C. S. Elton's classic work The Ecology of Invasions by Plants and Animals (New York: John Wiley & Sons, 1958) offers yet another perspective, while C. D. Sculthorpe's scholarly tome The Biology of Aquatic Vascular Plants (New York: St. Martin's Press, 1967), a "heavy" compilation (610 pages) of botanical detail, will be less useful to the nonbotanist. A 1973 report, "Some Prospects for Aquatic Weed Management in Guyana," as well as related information on some of the projects

"The Panda that went to China..."



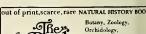
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eferred to in the author's article, is availible free from the Office of the Foreign Secretary, National Academy of Scinces, JH 215, 2101 Constitution Ave., Washington, D.C. 20418.

Alfred Moon's Farm (p. 74)

Standard textbooks of ecology will rovide the appropriate background maerial to explore further the concept of orest succession as a natural ecological rocess. A classical study may also be ound in the Journal of Forest History 1966, vol. 10, pp. 2-11) where H. M. laup gives "The View from John Sanerson's Farm: A Perspective for the Use f the Land." Copies of this and other apers on forests and land use in central lew England may be obtained by writing : The Harvard Forest, Petersham, lass. 01366. A Book of Country Things, s told by Walter Needham to Burrows Jussey (Brattleboro: Stephen Green ress, 1965, \$4.50), presents the converational reminiscences of an old farmer bout life on a Vermont farm. Vermont album, a collection of early Vermont hotographs assembled and described by .. N. Hill (Brattleboro: Stephen Green ress, 1974, \$12.95), contains portraits f Vermont hill farms similar to those nce found around Williamstown, Masachusetts. The nearly two dozen books y Eric Sloane, such as An Age of Barns New York: Funk & Wagnalls, 1966). ive some of the flavor of the life led by ie backwoods farmer. Sam Abrams's Notes from the First Frontier" in last pril's Natural History is a moving tribte to the farmers of the hill country of orthern New England. A 16mm, blackid-white, sound film, A Farm in Hopns Forest, from which the present arcle was taken, may be rented for a nomial fee from the Center for Environmental tudies, Williams College, Williamswn, Mass, 01267.

eather Wisdom (p. 104)

The U.S. Weather Bureau gave semificial sanction to the subject when it iblished Weather Folk-Lore and Local leather Signs by E. B. Garriott in 1903. ne of the most famous collections of merican oral traditions regarding eather prediction, it is readily available most libraries and in a reprint edition Detroit: Gale Research, \$11.00). W. J. umphrey's Weather Proverbs and Parloxes (Baltimore: Williams & Wilkins. 934) is the definitive, standard text on nglish and American weather folklore. ne uses of such lore by Shakespeare and ilton may be traced through the pseudoientific accounts presented in A Handook of Renaissance Meteorology by S. Heninger (Durham: Duke University

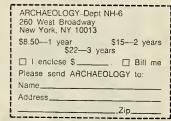
ess, 1960), a scholarly treatment of

iglish lore of the Elizabethan and Jaco-

an periods. The 4th edition of Richard wards's Weather Lore (1950), first

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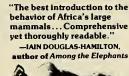
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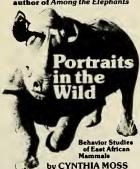


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published in 1869, is now available as an inexpensive reprint (New York: Barnes & Noble, 1971, \$6.50). The book's subtitle reveals the diversity of its contents: Taken from the World's Literature and the Age-old Wisdom of Farmers, Mariners, Bird Watchers, Concerning Flowers, Plants, Trees, Butterflies, Birds, Animals, Fish, Tides, Clouds, Rainbows, Stars, Mock Suns, Mock Moons, Haloes, Finland's national epic, The Kalevala, was compiled in the nineteenth century by the scholar Elias Lönnrot from old Finnish ballads, lyrics, and incantations. It has been translated into some twenty languages and has long influenced artists, composers (such as Sibelius), and poets (Longfellow patterned the epic style and meter of The Song of Hiawatha after The Kalevala). The two-volume work, translated by W. F. Kirby, is now available in inexpensive paperback reprints (New York: E. P. Dutton, 1961, \$3.95 each). V. J. Schaefer's "Observations of an Early Morning Cup of Coffee" (American Scientist, 1971, vol. 59, pp. 534-535) provides a delightful parallel to the author's Finnish farmer, as a scientist tells us how "through keen observation of an everyday item, one can learn much about the nature of convention and other physical phenomena."

Gordon Beckhorn

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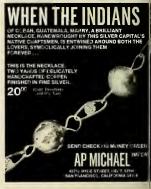
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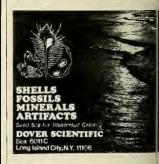
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VERBATIM POST OFFICE BOX 19

Announcements

he World in a Hat, which opened October, continues in the Corner allery on the fourth floor of The merican Museum of Natural Hisry. This multimedia presentation, art fairy tale and part fact, shows ow people use hats as emblems of atus in religion, politics, sports, soety, and jobs. Margaret Cooper's ory is narrated by Bess Myerson, ith drawings by Judith Rice.

n Sunday, November 9, at 2:00 M. the Rod Rodgers Dance Comany will perform in the main Audirium of the Museum.

Gallery 77 of the Museum, This xhibit in Preparation gives visirs a "behind the scenes" look at how different techniques are used to create the Museum's many marvelous dioramas and exhibits. Graphics, three-dimensional displays, and periodic demonstrations by artists, taxidermists, preparators, and modelmakers will reveal the inner workings of the Exhibition Department.

At the Hayden Planetarium of the Museum, A Year Full of Stars will run through December 1. This sky show explores the stars and constellations of the whole year as seen from all parts of the earth and reviews the astronomical progress of the past forty years, including such new techniques as radio astronomy and space satellites, which have enlarged our view of the universe. Sky shows begin at 2:00 P. M. and 3:00 P. M. weekdays, with more frequent showings on weekends. Admission is \$1.75 for adults and \$1.00 for children,

The following Film Programs will be shown in the main Auditorium of the Museum on Wednesdays and Saturdays at 2:00 P.M.: November 8, The Bakhtiari Migration, depicting the travels of Iranian nomads; November 12 and 15, Energy: The Nuclear Alternative and Islands of Green, on the greening of cities; November 19 and 22, Dinshvin. culture history of the Navajo, and Indian Relocation, a study in planned cultural changes; November 26 and 29, Death of a Legend, the wolf in fact and fantasy.

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HE PAST IS THIS YEAR'S BEST PRESENT.

According to their neighbors, the Finns are wizards and witches who control wind, rain, and frost. The Estonians, who live just to the south across the narrow Gulf of Finland, tell of a Finnish weather wizard who magically harnesses the wind and sells it to becalmed sailors. They also hold the Finns responsible for afflicting them with frigid north winds. In Two Years Before the Mast the American novelist Richard Henry Dana reports that "he had heard of ships beating up the gulf of Finland against a head wind, and having a ship heave in sight astern, overhaul and pass them, with as fair a wind as could blow, and all studding-sails out, and find she was from Finland.'

The belief in Finnish weather wizards dates to the Middle Ages, when commentaries spoke of Finns carrying the wind around in a bag or bringing a storm under control by tying

three knots in a rope.

No doubt, some of the Finnish reputation for magical control over weather can be explained by observing that much of the weather in Scandinavia and northern Europe seems to originate in Finland (more accurately, it passes over it on its way south). Nevertheless, part of this reputation is deserved, for there is a vast amount of weather lore in Finland. It is a rare Finn who knows none of the weather signs.

In the days before industrialization, weather was not merely a topic for casual conversation and over-thefence gossip. If the weather was not right, the Finns starved. This was the case in the terrible famine of 1696, when an early frost ruined most of the crops and a third of the population died. Contemporary chronicles describe wandering hordes of beggars and people eating the frozen carcasses of farm animals and bread made from pine bark. Weather is serious business in a country where less than 10 percent of the land is arable and the growing season is the shortest in the world.

Not surprisingly, the dominant motif in Finnish weather lore is fear of frost, the sudden freeze that can destroy a year's work. Most dreaded is the frost that strikes during the harvest. Frost figures not only in the folklore but also in classic works of Finnish literature. Frost, the son of North Wind, is also a major character in the Finnish epic Kalevala. He dwells in a place called Pohja, somewhere beyond Lapland. When this capricious boy wanders out of his territory, he bites the leaves off the trees and the grass off the meadows. And when Frost is not content to freeze stones or peel the bark off the birch trees in the north, he comes roaring south with such power that he can freeze the milk in the ewe, the foal in the mare, the housewife's hand in the breadough.

Because Finland is so vulnerable climatic extremes, its weather fol lore is particularly interesting. The folk beliefs discussed here represe only a fraction of the accumulate wisdom of peasants, farmers, an common folk. Most of this lore, co lected between 1880 and 1950, drawn from central and southern Fi land. Many of the beliefs have gre intrinsic charm. Some are rhyme poems filled with personification at images of startling beauty; others a hackneyed, overworked saws th have been quoted to death. A goo number bear the hallmarks of crud vigorous peasant speech: "Octob 18 is the day the fox pisses on the birch trees," the day the leaves tu yellow in the autumn.

Translating these sayings fro Finnish to English presents two prolems. The first is the loss of the poet sounds and images. The second is the relative poverty of English, corpared with the richness and precisit of the Finnish language. In Englis for example, the word for froze water is ice; to be more specific about the different qualities of ice, an English speaker must talk his way arout the subject with adjectives. Finnish more precise: jääkalvo is the first su face of the water, filmlike

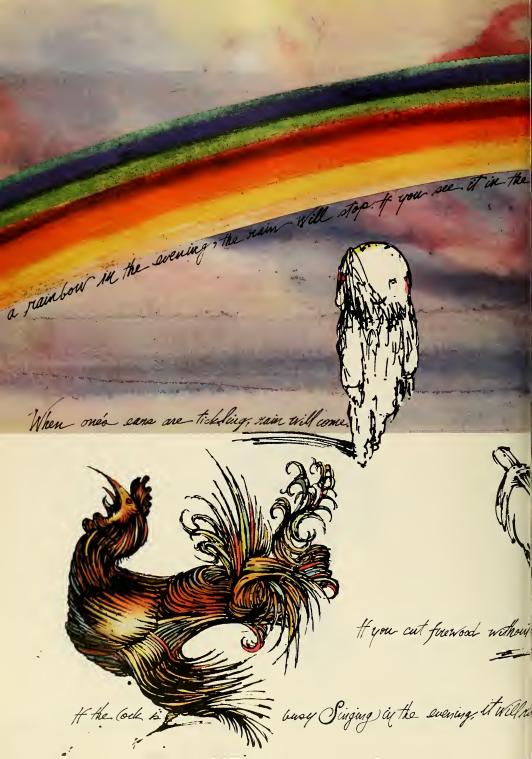
If a Horse Yawns, Rain Is Coming

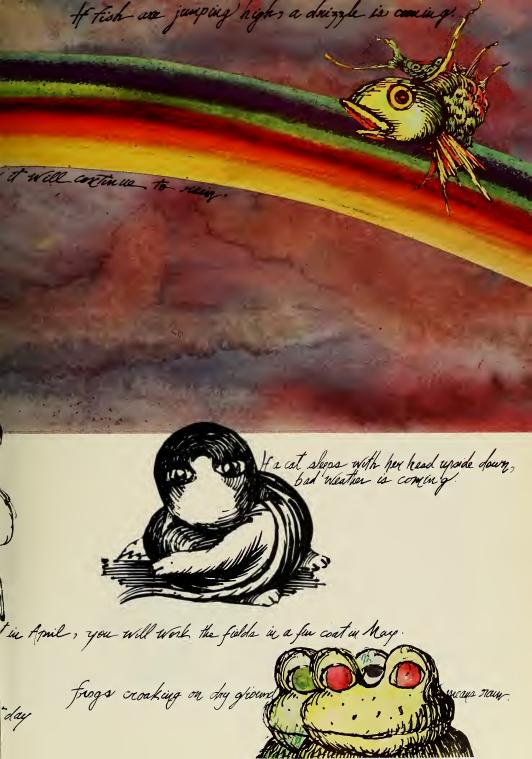
For traditional Finns, weather prediction is a serious, widespread, and colorful business

by David Andersen

illustrations by Ken Rinciari









When the moon has a ring around it, frost is coming.



nickness, but elastic in texture; jääuori is the next stage, best interreted as ice rind, when the thickness icreases to a few centimeters; sinää is the young winter ice into which his rind develops; teräsjää describes paque ice. Although the specificity f the language is lost in translation, opefully the reader will gain some ense of the precision and economy f Finnish proverbs.

Underlying each item of Finnish eather wisdom is a general assumpon, which one proverb crystallizes s follows: "The smooth days of Janary will be paid for in February and larch." In other words, unseasonble weather in one part of the year rows the cycle out of balance in anther part. Thus, the sun at Christmas buld mean frost at harvesttime. A ood year is one in which each season oes what it is supposed to do. A ood winter, then, is one in which the mperature drops below freezing and ays there: "The colder the winter is, e warmer is the summer." All Finsh weather lore is predicated on this rinciple of cycle, sequence, and balhee between cold and warm, rain nd drought, wind and calm. But the gh number of negative predictions r unseasonable weather, such as, If one cuts firewood without a hat April, he will work the fields in a r coat in May," suggests that this eal balance rarely occurs.

Where such predictions originated uncertain, but many of them, of ourse, were drawn from the experiice of the "folk"-from people oking out their windows or watchg the sky on their walks to and from e fields. If such observation led to weather sign, it was spread orally ithin the parish. Some of this lore as then spread throughout wider eas by means of planting calendars id farmers' almanaes printed during e nineteenth century. Although me of these predictions have their unterparts in the weather folklore other lands, they are not univerlly applicable. The earth's atmohere and areas of barometric presre, length of the seasons, and marine air masses vary so greatly from ace to place that it is often difficult compare the weather folklore of o regions.

The Finnish year is divided into ght seasons. Instead of abrupt shifts

from one season to the next, the Finns perceive a year as gradually changing from spring to spring/summer to summer to summer lautumn. Winter has three stages: syystalvi, or autumn/winter (November and December); keskitalvi, or high winter (January and February); and kevättalvi, or winter/spring (March and April). In some cases the Finnish names of the months reflect the dominant weather—May is "seed time," July is "hay time," October is "mud time," November is "dead time."

Each day in the month has a name as well as a number. These "name days" were originally based on the saints' calendar but later calendars have included secular names. One large group of proverbs refers to the name days, much as one might speak about an old friend or enemy. If, for example, Saara (July 19) "wets her feet [rains], it will rain for seven weeks." One of the most important days for weather forecasts is May 18, the day of Eric. Cold Eric is a good sign; warm Eric, a bad one. At Tottijärvi, rain on Eric's day means a good year for hay. At Koijärvi they listen for the cuckoo: "If you cannot hear a cuckoo on Eric's day, you will not find merry harvesters [in autumn]." In many parts of the country Eric's day is the day to let the cattle out from their long winter in the cowshed. At Alavus they say that "Eric opens the sower's hand, while Urpo [May 25] closes it.

Another set of sayings is associated with a "key" day, usually an important feast day on the Lutheran calendar. These key days are thought to control the weather that follows them for weeks or even whole seasons, but their influence is clearly more supernatural. At Töysä, for instance, rain on Easter Sunday, brings a chilly summer. At Ilmajoki a sunny Easter means a good crop in the autumn, but for the berry pickers of Kylmäkoski, rain at Easter is good luck.

In addition to name days and key days. Finnish weather predictors placed great reliance on the beasts of the field and the wild creatures of the wood. They believed that by closely observing behavior patterns in some animals, they would become alert to natural changes. In this class of weather predictions the animal most often mentioned is the cat. Cats seem

to be particularly sensitive to weather changes, and because they live with human beings, they are as accessible as a barometer on the wall. One widespread belief holds that "if a cat sits looking out the window, it means rain is coming." This saying occurs all over Finland, but one 80-year-old man, in a classic example of post hoc, ergo propter hoc logic, contributed his own variant, "You must not let the cat look out the window because bad weather will come."

Observations of other animals, particularly domestic ones, contributed to such sayings as, "Young cattle are nervous before bad weather" and "When you slaughter a pig and find it has a long spleen, the winter will be long too." But the behavior of wild animals—crows, hares, fish, and insects—could also be used to predict changes in the weather.

The most ancient weather signs derive from observation of celestial occurrences. The changes in the phases of the moon and the conditions under which the sun rises and sets are universally accepted prognosticators of weather. Most of the Finnish sayings about "skyey influences" are concerned with halos, coronas, and rainbows, all of which indicate the amount of moisture in the air. In addition, the presence of the northern lights provides the Finns with a sign unknown in many folklore traditions. The one shortcoming of all such signs is obvious; the weather must be clear to make these observations.

Finally, among the rich store of Finnish weather wisdom are many sayings and proverbs that defy classification. Coffee, smoke, burning embers, waterfalls, and broken bones all supply predictions for the close observer. Many of these isolated beliefs are characterized by homeliness and accidental discovery. To illustrate, a farmer sits drowsily over his morning coffee, as he has done hundreds of times. Dropping a few lumps of sugar into his cup, he sees something he never noticed before-little drops of liquid jumping into the air. When he goes out to work in the fields that day, it rains and the wind blows. After several more morning cups of coffee combined with rainy days, our anonymous coffee drinker comes to a conclusion about drops of coffee flying into the

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□ Enclosed \$5.00 for Confidential Prospectus on the Decoded New Testament and the Secret Church All Montes are U.S Tax Deductible Contributions air and the kind of weather he experiences after he has seen this phenomenon. We are left then with this bit of wisdom: "If lumps of sugar are put into coffee and little drops jump up in the air, bad weather is coming.' No doubt, the discovery of the cause and effect relationship in this belief is much more complex than my example indicates, but still the "homemade" quality of the belief is clear. One might speculate about the effect of atmospheric pressure on the coffee and sugar, but whether the belief is verifiably accurate or not, this is a classic illustration of how a simple domestic observation might blossom into a major scientific discovery.

If we regard these weather beliefs merely as fragments of ignorant superstition and idle speculation by

uneducated people, they have little value. But if we see them as a cumul lative commentary on these people then we can begin to understand theil function. By personifying its powers the Finns imply that weather is ani mate, something to be watched so that it does not sneak up on you. Like a human friend or enemy, the weather can be dealt with if one is prepared Furthermore, Finnish weather wis dom assumes that man is not jus "in" the rain or sun but "of" it Rain, snow, sun, and wind sculpt th figure of man as well as the land scape. Modern man may think he ha escaped the whimsies of weather i his microenvironments, but as tradi tional Finnish people well know, it i always out there, waiting-now soft now murderous.

Finnish Weather Proverbs

If a cow's droppings are frozen in September, they will thaw in October.

If the lanes are full of snow on Candlemas (February 2), so the bins will be full of corn in the autumn.

If March doesn't show the ground, then neither will April.

There will be as much rain in the summer as there is foggy weather in March.

If a dog pulls its feet up high while walking, a change in the weather is coming.

Pigs carry straw into their sleeping places before cold weather comes; when warm weather comes, they carry the straw back out.

If the magpie, the crow, and the hawk are quarreling, rainy weather is coming.

When flies are eager to bite people, rain is coming.

If waterfalls are roaring loudly, bad weather is coming.

When smoke goes from the roof straight to the ground, bad weather is coming.

When bubbles are rising on the surface of the coffee and they hold together, good weather is coming. If the bubbles break up, weather you don't need is coming.

In frosty weather, horses are lazy and just lie in their stalls.

If the pig wallows in a puddle before the first of May, the summer will be cold.

When goats come home from the field in the middle of the day, then rain is coming.

If soot on the bottom of the pot burns, snowfall will come.

When an old cow raises her head high and sniffs the air, soon a change to nasty weather will come.

When the cows come home with hay pieces dropping out of their mouths, then rain will come.

If it is raining on New Year's Day, it will rain when it's cutting and haymaking season.

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Turkey in the Slaw

His origins are confused, his intelligence questionable, but this not-so-all-American bird's welcome at the dinner table is undisputed

As the Bicentennial year grinds inexorably toward Thanksgiving, it is altogether fitting and proper, not to say obligatory, that we should all contemplate the turkey. If there ever was a time to scrutinize the nature and tradition of *Meleagris gallopavo*, this, my fellow Americans, is it. Unfortunately, like so many of the commonplaces of patriotism, the turkey, when closely examined, does not live up to its reputation as a purely native American phenomenon.

True, the various wild turkeys that ranged the forest floors of the pre-Columbian New World from Maine to the Yucatan did originate in this hemisphere. The colonists at Plymouth and elsewhere along the eastern seaboard did, undoubtedly, gnaw festively on turkey legs. And we may even credit that hoary legend of the first Thanksgiving without unwise suspension of disbelief. Wild turkeys, their tails tipped brown, were indeed available as a woodland bounty for the otherwise softly groaning Pilgrim board. And early Virginia colonists did begin another sort of tradition by raiding Indian turkey traps for Christmas fowl.

The trouble with these stories is that they imply an original kind of celebration-a New World bird eaten for the first time at a New World feast in a white Anglo-Saxon settingwhereas the turkey had gobbled its way to culinary celebrity long before the Mayflower sailed. And its first apotheosis came, so far as we know. among the Aztecs, who braised it and ate it on special occasions in a hot sauce containing chocolate. The dish survives in modern Mexico, as mole poblano de guajolote. The authentic ur-turkey recipe, then, belongs to the heritage of speakers of Nahuatl, not English.

The Daughters of the American Revolution cannot even fall back to claiming that the turkeys they now eat descend from wildfowl domesticated by their foremothers on American soil. The first domesticated North American turkeys were, in fact, imported from Europe. The Black Norfolk and White Holland varieties came to the British colonies from England, where they had first been bred. The first truly American hybrid, the Mammoth Bronze, was bred later, at Point Judith, Rhode Island.

Worse yet, Europeans in the colonial period had no idea that they owed turkeys to the New World. They confused them with guinea fowl, whence the generic name, Meleagris, which means just that. The Linnaean species name, gallopavo, also betrays confusion. It means chicken-peacock. But all this is only learned error. Our colloquial name, turkey, arose from a parallel conflation of avian identities. The guinea fowl was imported to Europe via Turkey. One thing led to another, you see, it being so hard to keep all those strange foreign places straight. (Think also of guinea pigs, which really came from Guiana.) Why, in France they thought turkeys came from India (d'Inde). Eventually, the apostrophe dropped out, leaving the modern French word for turkey, dinde. (French guinea pigs also are supposed to have come from India; they are cochons d'Inde.)

Domestication followed close on the heels of those first misnamed turkeys imported to Europe in the early sixteenth century. At a wedding in 1560 in Arnstadt, Germany, 150 birds were slaughtered. Flocks were thriving on the lower Rhine by 1571. In France, Charles IX feasted on turkeys at a special dinner in 1570. And the English custom of the Christmas turkey was established in 1585.

Meanwhile, ordinary people came to know the turkey as an awkward, not overly brilliant barnyard fowl. Although grateful for its ample breast meat, the French seized on the bird's stupidity and took to calling any dupe a "turkey." Similar ill will has led to the slang expression "turkey," for a failed play.

Probably, the turkey's most notably unintelligent trait is the propensity of a hen to sit on her nest for day on end without moving. Unless the are nudged into motion, some turkey will sit still until they literally stary to death. Furthermore, turkeys loc stupid, with their featherless head and gawky necks and oversize wa tles. But they are, or can be, del cious, and they are very cheap thes days, well under a dollar a pound From a luxury food to a staple on the tables of poor people and prisoner turkey meat-either fresh, frozen, o pressed into a loaf-is a bargai whose availability we owe to poultr science and to the basic adaptabilit of this giant in the Galliformes peck ing order.

Like the chicken, the turkey can double its birth weight in about tweeks. This compares with 180 day for a similar average weight gain human beings; horses take about 6 days, cows 47, goats 22, sheep 15 hogs 14, dogs 9, and rabbits 6.

Turkeys also progress to marke able weights with exemplary speed. And they have certain other econom advantages over mammalian meat a imals. Again like chickens, turkey birth schedules can be artificially mipulated. Eggs, once laid, can I held under refrigeration for signicant periods of time, until the hatcery is ready for a new batch. The opmum holding temperature is 50 d grees Fahrenheit and ten to fourted days is the maximum holding perio

Modern incubators and brooding coops also bring enormous efficiend to the turkey breeding process. In a automated incubator, the 28-da hatching period can be controlled that egg temperature increases grad ally from 1011/2 degrees to 104 d grees. At the same time, the eggs a automatically turned every four to s hours so that the embryos do not a here to the shell membrane. The inc bator also simulates crucial natur processes by producing regular cod ing for the first twenty-four days a by maintaining a relative humidity 60 percent. This atmosphere allow the eggs to lose internal moistur which, in turn, reduces the weight the egg and the size of the unhatch





G Lady on a camel



E La toilette



A Indra, the Thousand-Eyed One



C Girl in red dress with yo-yo



D Maharata horseman



F Four birds



8 Krishna milking

The Kashmir Collection

- A Indra, the Thousand-Eyed One, riding his white elephant. Tira-Sujanpur school, c. 1780.
- B Krishna milking, observing his beloved Radha. Basholi school, c. 1750-1755.
- C Girl in red dress with yo-yo. Basholi school, c.
- D Maharata horseman. Provincial Mughal art, unknown school. Early 18th century,
- E La toilette a lady contemplating her image. Bihar school. Late 18th century.
- F Four birds. (Inspired by a larger group from a natural history manuscript). Unknown school.

 Late 16th century.
- G Lady on a camel offering refreshment to her lover. Provincial Mughal art. Mid-18th century.

In the far-off Vale of Kashmir, something extraordinary is happening. A handful of great masters is combining the delicacy of Indian miniatures with...

The Exotic Art of Kari-Kalamdari

t is written that in the year 1237 a Sufi from the Kingdom of Persia, one Ali Hamdan, ventured into the Hindu land of India to read the word of Mohammed. Among his sciples were several skilled in the art of pier-mâché. The earliest-known object fashned from this incredibly light yet strong aterial was, not surprisingly, a reading stand r the sacred Koran. Another was a pen box, kalamdan, from which kari-kalamdari (the ersian word for papier-mâché) is derived.

Two hundred years later, Zain-ul-abiden avelled to the court of Tumer in Samargard discover new arts and crafts he could bring ck to his people. When he later became the dd Shah (Great King) of Kashmir, he ought masters from abroad to teach his substs these new disciplines — especially the art papier-mâché. Kashmir has been the center papier-mâché in India ever since. But nile the Bud Shah sought perfection, and me who followed him hewed to his standards, the drift has been downward. The state the art deteriorated. Something had to be ne to save this great heritage.

The birth of Mughal miniatures

As early as the 10th century, Indian arts had been painting lush miniatures to istrate Buddhist texts. But the Persians who nquered India in 1526 and created the ughal empire preferred the more refined rsian style. They sent envoys to recruit lled miniaturists from such centers as Taband Shiraz and Isfahan, and the Indian ists soon learned to minie them.

It was during the forty-nine-year reign of that the Great that the lusty Indian tradin was married to the technically superior rsian art. Akbar established workshops oughout his empire and encouraged both rms of art. Mughal rajas competed for the est talents, elevating the prestige of artists. We result was the classic Mughal miniature.

This genre is characterized by subject there of historical narratives, animal studies d landscapes executed with a romantic real-a that is achieved by the use of precise yet issuous lines and rich, bold colors. Unfortately, the splendors of Mughal miniature inting were short-lived; when the empire integrated in the mid-18th century, so did s school of art.

The Kashmir Collection

When the splendid history of the Indian s of papier-māché and Mughal miniatures ne to the attention of Collectibles, Ltd., an nerican group interested in traditional art ms, it decided to sponsor a native revival mbining both forms. A representative was patched to Srinigar, the center of Kash-

mir's papier-mâché industry, to gather together the greatest of its master artists and craftsmen. The prospect of reviving the glories of their own heritage was enormously exciting to these proud people and a keen competition developed to determine which masters would be chosen for the project. Seven were finally selected, each with several team workers. Included were the all-important apprentices who will carry on the revival in future years.

The seven boxes shown on the opposite page, the Kashmir Collection, represent the first summer's work. They average three inches in length, one and one-half inches in



height. Each box has a distinctive shape, and each is graced by a freehand interpretation of a famous miniature on its lid. The seven designs in this edition represent major Mughal schools, and depict classic scenes from Indian life, religion, and fable. The sides of the boxes are decorated with traditional patterns.

The Kashmir Collection of seven karikalamdari boxes is available in a handwoven willow hamper fully lined with Indian velvet.

CREATING A MINIATURE MASTERPIECE

In the 500 years since papiermâché was introduced in the Vale of Kashmir, little has changed. The artists and craftsmen still work slowly, carefully, and entirely by hand. The tools, methods, and materials are the same as those used centuries ago.

Six apprentices work under the tutelage of a master in applying papiermâché to a handcarved wooden mold. When the papier-mâché has reached one-eighth inch in thickness, the box is dried in the sun for two to four weeks. Once cured, it is covered with old limestone, smoothed with pumice, and covered with a special paper that takes the sealer paint exceptionally well. An advanced apprentice applies three coats of the base color. Only then does the master artist take over. He paints entirely freehand, as does another master who executes the Mughal designs on the sides of the boxes.

Finally, the painted box is protected with three coats of clear lacquer and is rubbed and lightly sanded between each coat. From start to finish, it has taken fourteen artists and craftsmen seven weeks to produce each box in the Kashmir Collection.

The price of the Collection, including the hamper, is \$175. However, only 100 sets of this quality can be produced each month and purchasers must understand that orders will be filled strictly in the order in which they are received.

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poult just enough so that it can move about inside the shell and eventually peck its way out into the world. An average weight loss through transpiration is 12 to 13 percent. This also leaves an air bubble, or cell, inside the shell. Experienced poultrymen can gauge their success by noting the size of the air cell when they candle their eggs. Candling (examining eggs by holding them between the eye and a light) also reveals dead eggs through dark spots that show up under illumination.

Humidity matters even after the young turkeys emerge, for if the air is too dry, the poults will chill from excessive evaporation of body moisture. This danger imperils all young poultry hatched in incubators, but turkeys are particularly susceptible.

They are, moreover, susceptible to a multitude of evils if they are subjected to artificial brooding. Typically, fifty poults will spend four to six weeks in coops (made of wire mesh to facilitate cleanliness) with a floor space of four square feet and walls fourteen inches high. The crowding and boredom of the brooding coop and the absence of a mother hen to provide diversion can lead to perverse and destructive habits. Turkeys sometimes take to eating their droppings or pecking at each other, pulling feathers, or impacting their digestive systems with sand. They may also pile up in warm places in the coop, where the sun hits the roof, for instance, and smother each other.

Release comes when a turkey reaches a weight of one and one-half to two pounds, usually in the sixth or seventh week of life. By twenty-six weeks, an average bird can attain over eighteen pounds. Full adult weight for a Bronze Mammoth cock is well over thirty pounds.

These large and rapid gains are possible because of a simple but efficient digestive system, which is ideally suited for converting tough-hulled grain feeds into usable nourishment. The turkey's elongated esophagus is an elastic tube with a pouch midway where feed can be held and exposed to digestive juices. This nutritional staging area, the crop, or craw, is officially called the ingluvies. From the crop, the food passes down the lower gullet, into the stomach (proventiculus), and from there to the gizzard.

The gizzard (gigerium) is really a biological mill, a muscular chamber that grinds up grain, often with the help of grit previously ingested by the bird. (To cook gizzards without having them go tough, peel away the outer membrane, simmer in water for thirty minutes, dice, and add to soup.) Finally, food passes from the gizzard into the intestinal tract.

And so, after a short and regimented life, Tom Turkey ends up —slaughtered and plucked—on the

kitchen table, ready to be cook Then comes the trouble. Assum you have ordered a fresh-killed, a frozen turkey, you must still c tend with a basically insoluble pr lem: roasting a bird that is "tw birds. Turkey breasts always tend be done long before turkey le Many dodges have been artfr evolved to get around this dilems I offer one below. I am also taking liberty of including a Serbian red for turkey with sauerkraut. If seems bumptious and unpatriotic remind you that the domestic tur is an immigrant and the feast Thanksgiving itself is the prototy cal celebration of American im grants-strangers in a new world

Although the combination of key and sauerkraut is not unknow this country, this version, called p varak, came to me from a recent migrant from Yugoslavia, where a major festive dish of winter. It become one of my favorite disl The juices of the turkey merge magnificently with the sauerkraut one almost feels that the turkey it is a secondary feature of the m The kraut is what you will rememl along with, perhaps, a renewed visceral sense of what is meant by pluralistic society.

Raymond Sokolov is a free-lof food writer. His novel, Native Int gence, was published last spring

Gena Fine's Podvarak Turkey with Sauerkraut in the Serbian Manner

½ pound lard, approximately 2 large onions, peeled and chopped ½ cup chopped parsley 2 cloves garlic, peeled and chopped 1–3 chili peppers, crumbled 1 tablespoon Hungarian paprika 3 quarts sauerkraut, drained, rinsed, and squeezed dry Salt

Salt Pepper 1 8–9 pound turkey

- 1. Preheat oven to 350 degrees.
- Melt 6 tablespoons of lard in a large skillet (or in two medium skillets).
- 3. Sauté the onion in the lard until translucent. Stir in parsley, garlic, chili peppers, and paprika. Then add sauerkraut, a handful at a time, stirring until well blended with the other ingredients. Continue stirring and sauté until the

- sauerkraut mixture has turned golden brown. You will probably have to melt an additional half cup of lard into the skillet to smooth out the mixture and keep it from burning.
- Add salt and pepper to taste. Then stuff the turkey's cavity with as much sauerkraut mixture as possible. Close the cavity and truss the turkey for roasting.
- 5. Spread remaining sauerkraut mixture over the bottom of a roasting pan just large enough to hold the turkey. Dot the sauerkraut generously with lard, and put the turkey, breast up, on top of the bed of sauerkraut.
- 6. Set the roasting pan, uncovered, in the oven at a level just below the center (so that the turkey itself cooks in the middle of the oven). Roast for approximately 2¾ to 3 hours or until a roasting thermometer placed in the thickest part of

a thigh (but not touching the be registers 180 degrees. Baste turkey every 15 minutes. If you not find enough pan juices basting, add a cup of chic stock or water and replenish liquid as necessary. During last half hour of roasting, fol sheet of aluminum foil over turkey breast to keep it from a ing out.

Yield: 8 generous servings

Note: Step 6 is a non-Serbian roas method. If you already have yown favorite way of tackling turk in the oven, use it, but be careful the exposed sauerkraut does not out and burn. Either add liquid to as above, or melt in more lard. The will probably be some leftover sakraut. This is not a problem. Relit and serve with sausage. Serbs to eat unsweetened cornbread witheir podvarak.





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Cover: A nineteenth-century lithograph depicts John Canoe, one of several masked characters that figured in the Christmas celebrations of West Indian slaves. Accompanied by boisterous attendants, John Canoes bellowed through the streets and were rewarded with a few small coins. Lithograph by I. M. Belisario, from the Institute of Jamaica collection. Story on page 82.

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Authors

Born in South Wales, Peter G. Hiley did his undergraduate work in Scotland and received a master's degree from the University of Nairobi, Kenya. While in East Africa he studied several primates (chimpanzees, baboons, bush babies), as well as zebras, rhinoceroses, and elephants. to learn how mammals regulate their body temperature. At present a graduate student and research assistant in the Department of Animal Science at the University of British Columbia, Hiley is planning to specialize in the problems of agriculture in developing countries.





Although he never mined coal himself, Tom Oakley's knowledge of mines and miners comes from an intimate vantage point. "I have seen my father return home from the pit, sometimes bloody, always tired," he writes. "As a member of a mining family, I am well aware of the past injustices to miners whose courage and fortitude is without match." A newspaper journalist for thirty years,



Oakley—now an editor at the South Wales Argus-regards his Welsh birthplace of Abertillery and its people as a lifelong preoccupation. Paul S. Conklin, a Washington. D.C.-based photographer whose pictures inspired the current article spent three weeks photographing the people of Abertillery, South Wales as part of his research for a children': book on Welsh coal mining.

State_

As an undergraduate working with a curator at The American Museum of Natural History, Howard Topoff developed a strong interest in army ants. Now a research associate in the Museum's Department of Animal Behavior, he has concentrated on the adaptive significance of the behavior of the immature members of an army ant colony. His field investigations of these ants have been conducted in Costa Rica, Panama, and Arizona. In addition, he has performed numerous laboratory experiments with them in order to unravel how they fit into the social organization of a colony. Topoff also serves as professor of psychology at Hunter College of the City University of New York.





As assistant professor of anthropology at Illinois State University, Robert Dirks specializes in Afro-Caribbean studies. In an attempt to add historical depth to his research on contemporary social organization in the British West Indies and gain insight into the attitudes of the slaves, he looked into descriptions of ritual expression, such as Christmas festivities, in the accounts of slave life set down by planters and travelers. Dirks has done field work in Tortola and Jamaica and is planning a detailed ethnographic film study of the Black Caribs of Central America.

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A Threat to Darwinism

An argument among geneticists raises fundamental questions about the theory of evolution

Scientists debate many important questions by inference because they have not found techniques for seeing directly. Restriction to the naked eye never halted speculation about the moon's structure. Galileo's telescope improved matters. But Neil Armstrong's small step superseded centuries of indirect inference.

In studying the influence of genes on the variability of organisms, we have until recently been forced to "see through a glass, darkly," as Saint Paul put it in a different context. We have had to rely mainly upon variations in morphology, a most unsatisfactory measurement. Significant trends in morphology may have no genetic basis whatever. The increase in height among wellnourished humans is our best example; think of it when you next bump your head against the door lintels of Old Ironsides or when you calculate how short Sir Lancelot and legions of bold heroes must have been to cram their bodies into most sets of medieval armor.

For more than seventy years, we have understood the genetic basis of certain easily observed traits: eye color in *Drosophila* or wrinkled vs. smooth peas, for example. But even though we were able to relate changes in morphology to certain genes, we still had no significant information about the genetic composition of whole organisms. What is the total

number of genes? How many are variable? We had no technique for finding definite answers. Yet these are important questions for evolutionary theory because natural selection cannot produce evolutionary change without abundant genetic variability to choose from.

The absence of information did not stop scientists from theorizing. Two opposing schools of thought battled for many years. One group, led by laboratory geneticists, held that only a small percentage of genes could vary in an organism. They argued that if many genes varied, then any individual would necessarily maintain a large set of relatively less advantageous genes. They tended to view the organism as a large beanbag, with each gene as a separate bean. They measured evolutionary "fitness" by adding up the advantages and disadvantages of each gene separately. If most genes varied, then each organism would have so many disadvantages that fitness would soon plummet to inviability. The solution to this paradox, they claimed, was that very few genes varied. Dobzhansky refers to this belief as the "classical" view.

Field geneticists, on the other hand, knew of the rich natural variability of form and behavior in life. They had difficulty reconciling this richness with such an underlying poverty of genetic variation. They argued that the additive approach to fitness contained a crucial error in concept. Natural selection does not "see" individual genes and work separately upon them; it views the entire beanbag as a whole and preserves the best beanbags. The more genetic variability, the greater the variety of dif-

ferent beanbags for adaptation to changing environments.

The classicists wanted, so to speak, to reject any beanbag with more than ten defective beans; if too many genes are variable, all beanbags will be so afflicted. The field geneticists argued that selection judges only the external form, structure, and function of the beanbag, and that if conditions change, today's "defective" bean may be tomorrow's salvation

A decade ago, two researchers, R. C. Lewontin and J. L. Hubby, discovered a way to get significant answers to questions about genetic variability. According to the "central dogma" of molecular biology. "DNA makes RNA makes protein," which is a way of saying that separate genes code for individual proteins Genes of higher organisms contain both a maternal and a paternal partone on each member of a pair of chro mosomes. The separate maternal and paternal contributions are called al leles. Both a maternal and paterna allele code for each protein in an indi vidual organism. Because of this Lewontin and Hubby realized that the well-known laboratory technique o electrophoresis could display genetic variability. Different forms of a pro tein have different mobilities in a electric field. Thus, we can extract protein from an organism, place it is an electric field, and routinely deter mine whether it exists in one or twstates. If the maternal and paterna alleles are different, a protein wil show at least two different mobilitie in electrophoresis. We then extrac the same protein from many orga nisms to determine how many allele the population maintains (each ind

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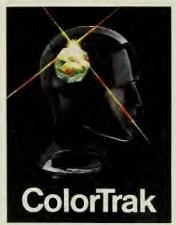
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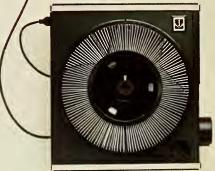
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KODAK GIFTS. FOR THE TIMES OF YOUR LIFE. vidual has only two alleles for a single gene, but the gene itself may exist in any number of alleles among members of a population). Electrophoresis has revolutionized the practice of evolutionary genetics; within a mere decade, hundreds of assessments have been made in scores of laboratories for the average amount of variability in structural genes.

The results may be unambiguously and succinctly stated: there is far more genetic variability within natural populations than the classical school could possibly allow—and even more than many field geneticists ever dared to imagine. In several organisms, more than half the tested genes exist in alternate alleles within a population, while individuals may be variable in up to 25 percent of their genes (although 5 to 15 percent per individual is the usual range).

Has this result ended the long concroversy? Not at all, for there is a way to rescue the classical view. The variation is there; cannot be denied. But if most of this variability is "neural," that is, if it confers neither advantage nor disadvantage upon an organism, then natural selection cannot work upon it and there are no defective beans. The classical view can itill be maintained. As long as there are few defective beans, the classical position is not threatened.

But something even more fundanental is threatened, namely, Darvinism itself. The Darwinian theory of evolution relies upon natural selecion to preserve favorable variants nd eliminate unfavorable ones. With neutralism, we have no control by seection since neutral alleles are invisile to natural selection. While neutralsts acknowledge that some alleles lave selective significance, they claim that only a small proportion of he total variation in natural populaions reflects a control by selection. Darwinian selection, metaphorically peaking, is a wind that can only nove the superficial skin of a deep cean of variability.

I shall defer a general discussion of neutralism to a future column (I am, or the most part, an unrepentant Darvinian). However, one issue in the tudy of natural variability has imporant implications for the hypothesis of neutrality. Once evolutionists discovered this rich storehouse of variability, they began to ask whether the amount of variability per se could be controlled by selection. For neutralists, the amount of variability can

only be a function of such properties as mutation rate, population size, and duration of a species. Evolutionists, on the other hand, might seek a correlation between amount of variability and an ecological situation.

In 1969, P. W. Bretsky and D. M. Lorenz published an important hypothesis linking variability to the nature of environments. They argued that animals living in unstable environments should maintain more genetic variability than those inhabiting stable situations. In unstable environments, organisms must maintain the potential for adaptation to rapidly shifting ecological conditions. If they maintain high variability, they will always retain enough alleles to confer success over an entire range of shifting circumstances. On the other hand, organisms of stable habitats (tropical reefs, for example) can specialize minutely on a single, constant resource. They might sacrifice flexibility in variation for precision in specialization. Bretsky and Lorenz then noted that mass extinctions of the fossil record exert a greater effect upon the inhabitants of stable environments. The opportunistic sacrifice of variability for immediate precision spells ultimate doom; when conditions change, as they must in the course of geologic time (even in the most stable environments), selection finds insufficient raw material to mold for adaptive change. Animals fall victim to their own previous success.

The plausible hypothesis has fared poorly as electrophoretic data accumulate. T. J. M. Schopf and J. L. Gooch studied genetic variability among organisms in one of the world's most stable environments, the deep sea. They found variability is not impoverished, as the Bretsky-Lorenz hypothesis requires. The starfish, sea cucumbers, crustaceans, and clams have as much genetic variability as their cousins in highly unstable, shallow coastal waters. F. Ayala and J. Valentine then studied an inhabitant of stable, shallow-water environments-the highly specialized, tropical, reef-dwelling giant clam Tridacna. The results were surprising. Not only did the giant clam provide no evidence for reduced variability; it actually exhibited the highest amount of variation in any organism known at that time (June 1973).

This interesting result prompted Ayala and Valentine to extend their studies to other organisms and environments. In so doing, they obtained results exactly opposite to the Bretsky-Lorenz hypothesis-organisms in stable environments have more genetic variability than inhabitants of unstable environments. The results are still sketchy and involve the comparison of unrelated animals (an antarctic brachiopod with a temperate horseshoe crab and a tropical clam, for example), but the pattern seems to be holding. Just recently, Valentine told me about some new and more satisfactory results. He has studied three closely related species of krill (small crustaceans), one from a highly unstable high latitude, the second from an intermediate temperate locality, and the third from the highly stable tropics. Genetic variability increases from the impoverished high latitude species to the highly variable tropical species.

Ayala and Valentine argue that this pattern makes sense in traditional Darwinian terms. Bretsky and Lorenz had confused genetic variability with physiological plasticity. An organism in unstable environments must be able to endure major changes in physical conditions. But the best path to this adaptation may lie in selection for genes that confer physiological plasticity rather than in increased variability itself. Highly stable, tropical habitats, on the other hand, encourage genetic flexibility by their very richness. There are so many ways to make a stable living in the tropics (compared with so few at high latitudes) that a species might adapt by producing a "wide variety of functional variants, each adapted to a slightly different milieu."

In any event, if Ayala and Valentine's correlation holds, the neutralists will be in for a hard time. If variation responds, not only in direction but also in amount, to the selective pressures of immediate environments, then most of that variability cannot be neutral. Quite apart from the merit of Ayala and Valentine's specific hypothesis, a potential correlation between amount of genetic variation and type of environment suggests control by selection.

The adaptive value of form helped to establish Darwinian selection more than 100 years ago. The adaptive value of variation may now rescue it from a serious contemporary challenge.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

The Water Fern-Rice Connection

By growing these two plants in the same paddy, farmers in North Vietnam have increased their rice yields

The water fern Azolla is usually studied by first-year botany students and professional botanists, but it is practically unknown to almost everyone else in the Western world. Together with two related genera, it belongs to the small group of ferns adapted to life in an aqueous environment. This makes Azolla interesting from an ecological and evolutionary point of view, but its small size, limited distribution, and apparent lack of economic importance have contrived to keep it obscure. For a surprising reason learned during a recent trip to the Far East, I believe this plant, commonly called the mosquito fern, is soon likely to become much better known and intensively studied outside the Orient.

Colonies of Azolla plants, each perhaps a centimeter in diameter, float on bodies of fresh water, their flat leaves arranged in two alternate rows for buoyancy. Each leaf has two parts: an upper green lobe-with stomata, or orifices-which is active in photosynthetic production of food, and a lower colorless lobe, which is probably useful in the absorption of water and minerals. Short roots, which extend from the junctions of the branches a few millimeters below the floating frond, also serve as organs of absorption, although their orientation may make them additionally useful as a keel for stabilizing the floating plant body. Reproduction is mainly vegetative-new fronds develop from buds that separate from the mother frond as the connecting stems break up.

For as long as men can remember, the peasants in several villages of Thai Binh province, the most intensively cultivated area in North Vietnam, have produced extraordinarily high yields of rice. The farmers attribute this bounty to the joint culture of rice and the Azolla pinnata fern in their paddies. In the winter season, when rice seedlings are transplanted, small starter colonies of the fern are placed in the paddies. They multiply rapidly by vegetative propagation and within one or two months completely cover the surface of the water. Growing together, the fern and the rice make the green paddies efficient absorbers of solar radiation.

An abundant growth of the fern is invariably accompanied by rice yields 50 to 100 percent greater than that achieved in adjoining paddies that are not "seeded" with Azolla. The relationship between the fern and the rice seems hard to understand until one realizes that the leaves of the water fern contain little pockets in which colonies of a particular strain of the blue-green alga called Anabaena grow. This alga not only fixes carbon dioxide into sugars by photosynthesis, it also fixes nitrogen from the air into forms that can be utilized by rice and are therefore of great value to the growth of the cereal.

It has long been known that *Anabaena* and two other blue-green algae found living free in the waters of rice paddies fix nitrogen, but the *Anabaena-Azolla*-rice mutualism has only recently been uncovered. It ap-

pears that the Anabaena-Azolla combination is much more efficient in fixing nitrogen than any of the free-living forms alone, although no one knows why; furthermore, the Anabaena that lives in the water fern's pocket is uniquely adapted to that special environment and will not grow well if removed from the pocket and cultured in the water of the paddy. Why this is so remains a mystery, but it can be presumed that the symbiotic alga strain has lost its ability to make some essential compound that is furnished in the pocket of the fern leaf. The alga, in turn, probably improves the growth of the fern by virtue of the nitrogen it fixes.

Only one or two villages in Thai Binh have traditionally been able to furnish "seed" colonies of water fern for inoculation into rice paddies during the winter transplantation. The fern tends to die away during the late spring and early summer; at that time the plant goes through a cycle of senescence and yellowing and is also subject to attack by insects that eat its fronds and roots. Somehow, the Tha Binh farmers learned over the years how to protect Azolla colonies from these dangers and when winter came they were able to sell small starte colonies at very inflated prices. So valuable was the water fern consid ered to be that the secret of protecting it, guarded by a formal set of taboo and restrictions, was passed on in: solemn ceremony only to youn; males when they entered into inde pendent family life and farming. 1 was never revealed to the women be cause they might marry outside th village and take it away with them.

As a result of food shortages during the thirty years of war recently concluded in Vietnam, the Thai Binh peasants were urged to share their secrets with others. The technique of Azolla preservation, it appears, involves regulating the acidity of the seedstock-producing paddy. Under normal conditions, a paddy becomes progressively more alkaline during the rice-growing season, and this favors the senescence and death of the water fern culture. If acidification to carefully prescribed formulas is carried out under conditions of high light intensity at the proper time of year, the cultures tend to survive. But even surviving fern cultures are vulnerable to insect attack. These are now successfully warded off by an organophosphorus insecticide called Wofatox, imported from East Germany.

Azolla culture is no longer a secret; consequently, use of the fern is spreading rapidly in the rice-growing regions of North Vietnam and even in southern China. In the absence of substantial fertilizer production and of the foreign exchange necessary for purchase of such materials abroad, the water fern may prove to be of critical importance in maintaining food production for an expanding Vietnamese population, expected to reach a total of fifty million in North and South Vietnam combined by 1980. But since ferns produce no seeds, Azolla culture will probably continue to depend on the careful hand manipulation of fresh starter colonies for some time to come.

Arthur W. Galston teaches biology at Yale University.



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The Tea Mystique

In many lands through the centuries, this drink has affected the way people live and worship

Next to water, tea, or *Thea sinensis*, is the most popular drink in the world. The volume of tea consumed each year in the United States exceeds that of coffee. In Great Britain, a "cuppa" is akin to chicken soup in Brooklyn, a panacea for everything from chilblains to broken marriages. In parts of the Orient, tea's ritual significance has literally altered the architecture and standards of beauty of the land. As with other plant products man has exploited, tea's impact on

culture has been extensive, and as all American schoolchildren know, it was a factor in the political development of the United States. Linnaeus named the plant Camellia japonica because his herbarium specimen came from Japan, but the shrub is actually native to India. It was known in China almost five thousand years ago and was taken to Japan a mere thousand years ago.

During the Han dynasty in China (206 B.C.—A.D. 220), the government transcribed a medical book written in 2737 B.C. by the legendary emperor Shen Nung in which *ch'a*, Chinese for tea, was reported as a cure for tumors, abscesses, and ailments of the bladder. Shen Nung emphasized

that tea "lessens the desire for sleep" and "gladdens and cheers the heart." Infusions of young leaves had a pleasant flavor and aroma that took the curse off the flat, insipid, boiled water that was used to prevent waterborne disease.

A reasonable explanation of tea's entrance into China is that travelers returning from India brought back seeds of the plant. By the fourth century A.D., reliable records on tea cultivation, processing, and brewing were being maintained in China. The method generally preferred by tea drinkers for processing the leaf was the tea cake, or brick tea, technique, in which young leaves were mixed with rice and baked; the resultant



Tea catches on in late seventeenth-century England

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cake was pounded into small pieces, boiled with water, onion slices, ginger root, and orange rind, and served to render one sober or to keep one awake. The peasants were content with older leaves, which they boiled in salted water.

By the early T'ang dynasty (A.D. 618-907) tea was an export product, taxes were levied on it, and a threevolume, ten-part tea classic (Ch'a Ching) had been written, extolling the pleasures of tea drinking and giving directions on growing, preparing, storing, and brewing. New varieties were selected from chance mutations and the techniques of processing leaves were perfected—basically the same ones in use today.

Baked tea cakes or less elegant infusions of leaves were supplemented during the Sung dynasty (960–1127)

with tea made from quickly dried leaves, finely powdered and whipped with hot water into a thick green froth. At about the same time, a splinter branch of Chinese Buddhism, the Ch'an sect, incorporated tea into its rituals. Subscribing to the Tao ideals of simplicity and contemplation as the road to enlightenment, Ch'an Buddhists used tea, which contains caffeine, to keep themselves awake during their vigils and as a ceremonial aid to induce the state of calm harmony that contemplation requires. Since the peasants were Buddhist (although the ruling class was Confucian), the popularity of tea among the masses was facilitated. This devotion to tea continued in China, even when the Mongol hordes conquered the land in 1279 and tea fell from favor in the Great Khan's





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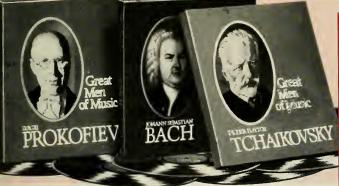


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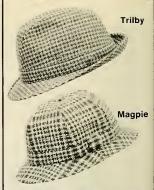
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court. Marco Polo, a guest of the court, did not discuss tea in his tales; he did not see or taste it, and Europe was consequently deprived of tea's solace for an additional three hundred

For many centuries, Japan was dependent upon China for protection and looked to the mainland for enlightenment and culture. The Japanese emperor obtained tea in A.D. 729 from his Chinese counterpart and invited a hundred Japanese Buddhist priests to join him in sipping the beverage, but having been improperly instructed in its preparation, the Japanese did not find the bitter, cloudy, almost black liquid particularly well suited to their palates.

Ch'an Buddhism was brought to Japan from China in the middle of the thirteenth century by a senior priest who founded the Sufukuji temple in the southernmost of Japan's four major islands. Along with the religion, called Zen in Japan, he also brought back tea and a few ritual tea vessels, but he did not know what to do with them. The founder of a Zen Buddhist temple in Kyoto, who was familiar with the Ch'an tea ceremony, subsequently modified it to be more compatible with Japanese concepts and gave the Japanese version its name—cha-no-yu—the ceremony of hot-water tea. As part of the naturalization process, the Japanese Zen sect developed its own legends about tea. The most famous is the story of a mythical Buddhist saint who, vowing to stay awake for seven years to achieve Zen enlightenment, fell asleep after five years. Upon awakening, he was furious; to chastise himself, he cut off his eyelids and threw them on the ground where they grew into a tea bush. Thus tea was considered a gift of the Gods.

The development of the tea ceremony in Japan had profound and often hidden repercussions. Initially a small sect, Zen Buddhism struck a responsive chord in the minds and hearts of the shoguns (the military governors) and their samurai warriors, who ruled Japan from the twelfth to the nineteenth century. They were trained to respect simplicity, austerity, and a ritualized code of behavior. Those who survived the bloody internecine fighting then rampant retired to a life of contemplation. Zen offered them concepts they could understand, and the ensuing symbiosis between soldier and priest resulted in both secularization of the



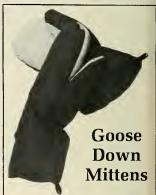
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tea ceremony and modifications in the design of formal gardens.

The eighth Ashikaga shogun, who constructed the famous Silver Pavilion of Kyoto, had a garden especially designed to set off a tea hut built by his tea priest within the pavilion enclosure. The hut became the inspiration for a new style of garden design. Originally a separate room within the main house, it was eventually transformed into a separate building. By the early sixteenth century, the Silver Pavilion's tea master and his patron had adopted the building style seen in Chinese brush paintings; the tea hut itself was essentially a rude, strawthatched shelter with a small door through which the celebrant entered on hands and knees. To facilitate the aura of austere harmony, the gardens surrounding the tea hut were converted from the earlier style of reproductions of forests and coastlines into a simplified design with the concept of nature purified and perfected as an aid to Zen communication.

The new gardens mimicked Chinese landscape paintings of the Sung dynasty (960-1279), with their emphasis on rocks and thick green moss, all pure and sunny warm. Plants became secondary to rocks, and in time, the larger tea gardens in Japan completely dispensed with plants. The flat garden, a miniaturized landscape, was constructed to provide the impression of a distant vista, and was so placed that participants in the tea ceremony could view it through the small windows of the tea hut. It was called shakkei, or "borrowed scenery," and has become a common modern Japanese garden design for small enclosed spaces.

The tea hut itself contained features that we now associate with Japanese life. Simplicity, elimination of luxury and ostentation, and the harmony that is necessary for contemplation were stressed. Details of construction were codified; internal walls were to be of rough, gray plaster, window openings should be of bamboo, the mats should not exceed a specified number, and the beams should retain the marks of the adz. Although it did not originate with the tea ceremony, the tokonoma, or traditional alcove, reached its present design perfection in the tea hut, where it came to symbolize the special Zen area for the display of a statue or painting of a saint. Precious scrolls, a lovely stone on a teakwood stand. or some other object of contemplation

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occupied a prominent place in this alcove. It was the responsibility of the tea master to place within it natural objects of profound and quiet beauty that would enhance the observer's spirit of harmony with nature.

Flower arrangements, which came to be placed in the tea hut alcove, and the development of ikebana, or flower arranging, are now intimately tied to the tea ceremony. In fact, from the sixteenth century on, the almost legendary arrangers of flowers were tea masters. The simple, austere, and delicate styles they originated have been perpetuated and modified into the schools of flower arranging that are common today.

The tea ceremony, its hut, its garden, and its plant arrangements embody two deeply rooted Japanese ideals. The first is furyu-no-asobi, approximately translated as an elegant amusement, "allowing one to lose one's self in the joy of delicate peace and tranquility." The second is the concept of wabi, or "mellifluous simplicity," in which every aspect of an act is carefully orchestrated and integrated. The point is that the tea ceremony is not simply the drinking of a frothy, grass green, bitter tea; rather, it exemplifies the combination of serenity, grace, and beauty that makes up the spirit of Zen and enables participants to enter that spirit through their involvement in a ritual of perfect harmony and tranquility.

Families willingly spend huge sums on a tea hut, ancient tea utensils, and the construction of a tea garden, for the tea ceremony has been overlaid with a degree of self-serving conspicuous consumption. Although still a quasi-religious rite, the tea ceremony is a part of the proper mode of conduct of the middle and upper classes in Japan. Young women take courses that teach them to serve as leaders in a tea ceremony and many also learn flower arranging, much as some of our children from comparable backgrounds learn to ride an English saddle or serve in a receiving line. A final note on the tea ceremony: the traditional number of participants was five; thus, in Japan, glasses, cups, and other tableware are normally sold in sets of five instead of the units of six, eight, or twelve we are accustomed to in the West.

Tea entered European awareness in the middle of the fifteenth century through the narratives told by travelers returning from the mysterious East. It so piqued the curiosity of the nobility that the Portuguese, who had forcibly established themselves on the island of Macao in the South China Sea, sent back a few chests of

for the home.



leaves in the hopes that a market for tea could be established in Europe. Little came of this venture, however, and Portuguese traders continued to confine themselves to silk, rhubarbfor the constipated—and curios. The Dutch East India Company first obtained tea from the Portuguese, found it a pleasing drink, and after establishing their influence over the major islands of Indonesia, moved into the Chinese tea trade. Trade relations with the tottering Ming dynasty were poor, and the ascendancy of the Manchus in 1644 did little to help the situation. Traders were confined to the single port of Canton in the south, where ch'a was called t'e. The Dutch forced the Portuguese out of Canton and obtained a virtual monopoly on the then burgeoning tea trade.

Russia got its tea through a single trading town, Kyakhta, on the then Russian-Chinese border. Isolated from the rest of Europe, Russia developed its own tea-drinking style, which was different from either China's or that of Europe. Its characteristics—the samovar, serving tea in glasses instead of cups, sweetening the beverage with a spoonful of jam, or sipping the hot brew through a lump of compressed sugar held between the teeth—are still largely confined to the motherland. The Russians

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did, however, export the lemon slice.

Not unexpectedly, as tea filtered down from the European nobility to the less-exalted classes, it came under the scrutiny of the medical profession. Cornelius Decker, a seventeenth-century doctor and sometime drumbeater for the Dutch East India Company, wrote that "an obstinate fever could be cured by drinking every day forty to fifty cups of tea.

. . . '' Contemporary French medical authorities were, for the most part, antitea; the entire Collège de Médecine denounced "this dubious drug." Its few advocates made such extravagant claims for its medicinal value that the French gave a Gallic shrug and went right on drinking wine, a native product that was far less expensive than tea. Germany preferred beer, and Spain, Italy, and Portugal were priced out of the tea market by the Dutch, whose hatred for the Latin countries had an unhappy historical base.

In the late seventeenth and early eighteenth centuries the British were still primarily coffee drinkers, obtaining their supply from their tropical colonies. London had almost 500 coffeehouses, exclusively male enclaves, which were centers for business, gossip, gambling, and literary and political discussions. In 1660, a London shopkeeper tried to promote tea by claiming that "it maketh the Body active and lusty, eliminates the gripping of the guts and the pains of the Bowels." But the British were not about to pay the exorbitant tea prices (\$50 per pound) demanded by the Dutch. Tea at that time was an article of snob appeal. Samuel Pepys tried it but did not like it. Charles II, however, was charmed by the diplomatic gift of tea from the British East India Company. Not surprisingly, the royal example sparked an interest in tea drinking. Pepys tried the beverage again in 1667 and this time he apparently liked it.

In the second half of the seventeenth century, Charles gave the British East India Company an absolute monopoly on tea importation, freezing out the Dutch. With that assured market, the company established a regular tea run from Canton and Amoy. When afternoon tea was served by the Duchess of Bedford in 1680, the news swept the land and tea began to threaten the place of coffee in the social life of Britain, Imports of tea rose from less than one hundred pounds in 1680 to a million pounds

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in 1700. By the turn of the century, the London coffeehouses all served tea as well as coffee. Thomas Twining built an annex on his coffeehouse, the Golden Lion, and became wealthy serving tea there to the ladies. He and his imitators further popularized tea drinking by importing handleless Chinese procelain teacups through the East India Company. To protect the ladies' delicate fingers, the British pottery firms of Spode and Wedgwood added handles to the cups. Matching saucers were soon suppled, and with the rediscovery in Dresden by the middle of the eighteenth century of the ancient Chinese art of porcelain making, elaborate tea services became appropriate wedding gifts for the middle class. In short order these modified Chinese designs were translated into silver by the Georgian silversmiths.

By 1780, London coffeehouses were really teahouses, the gin mills of the slums were becoming tea bars, and tea imports rose to 14 million pounds a year. Samuel Johnson called himself a "hardened and shameless tea-drinker, who has for many years diluted his meals with only the infusion of this fascinating plant" and confessed that he drank up to twelve cups of tea at a sitting. John Wesley, the eighteenth-century English preacher and founder of Methodism, denounced those weak-willed people who had substituted one evil-tea-for another-liquor-but he finally succumbed to the allurement of tea and had a special pot made for him by Josiah Wedgwood. The Temperance Society, along with others who had embraced tea, used the drink as permissible liquid solace. But the East India Company was in trouble. In anticipation of huge sales to the American colonies, it had in storage millions of pounds of tea that the colonies refused to buy because of the tax on it. The colonists were still drinking tea but it was smuggled into eastern ports by the Dutch and down from Canada by enterprising French Canadians, who had little love for the English. The rest of the early American tea story is history.

Although very different in style and concept from that of the East, the British, too, developed a tea ceremony. A social rather than religious event, afternoon, or low, tea was originally a submeal between the big noon dinner and the late evening sup per. With its traditional watercress sandwiches, scones, and bread and butter with jam, low tea is considered

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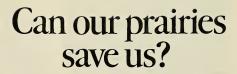
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Can we save our prairies?

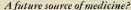
Prairies once covered one-third of the U.S.

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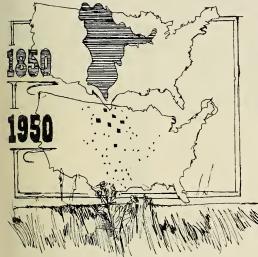


Some species of plants are so rare, a single housing development could wipe them out. Where would medicine be today had this happened to the *Penicillium* mold? By preserving our prairies, TNC is providing living laboratories for ongoing experimentation.

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a time of calm in a busy day. Low tea has its own code of behavior governing the art of holding the cup and the protocol of pouring. High tea, on the other hand, served in the late afternoon or early evening, is a full meal in itself, usually associated with the lower classes.

Iced tea was invented at the Saint Louis World's Fair of 1904 by Richard Blechynden, an English public relations representative of a Ceylonese tea company. Arriving on a beastly hot day with a group of Sinhalese waiters in colorful native dress, he was unable to find any takers for his hot beverage. With the genius of a good PR man, he poured the hot tea over ice, added sugar and lemon, and created a sensation.

The tea bag, an object of scorn to the British, was the inadvertent invention of Thomas Sullivan, a New York importer and wholesaler. In 1908 he decided to send out his samples in small silk bags instead of the usual tin caddy. Some unknown sadomasochist dropped a bag into hot water and yet another fine product was started on the road to degradation. Rock bottom in the art of making tea may have been reached with the development in the 1940s of instant tea.

There are three main types of teablack, oolong, and green-and many hybrids. Stimulated by previous pickings, tea plants show a flush of new leaf development at about weekly intervals. The two new leaves formed at the tips of each twig are plucked by hand and spread out on racks to wither, thus reducing their water content. The now soft and flexible leaves are then passed through rollers that break up the leaf cells and liberate the cell sap contents responsible for flavor. Rolled leaves are broken up and spread out in a cool, humid atmosphere to undergo fermentation. This results in a complex, poorly understood series of chemical changes that produces black tea. Oolong teas, now rarely seen, are given a shorter fermentation period, and green teas are not fermented at all. Finally, the leaves are dried with heat, sorted by size, and blended. Our popular teas, Orange Pekoe, Pekoe, and Pekoe Souchong come in two leaf grades: the larger leaf fragments are used in brewing, while the finer leaf fragments are used more extensively in tea bags.

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as the altitude and climate of the growing region; the methods of harvesting the young bud leaves; processing by drying, fermenting, and rolling; and appropriate blendings of different types. Some blends, initially created for the English nobility, are world famous, for example, Queen Mary and Queen Ann. The leaves, twigs, and bark of many plants can be infused in hot water and, based on the same process of generalization that plagues companies producing trademarked products, are often called teas. Thus we have mint, camomile, and sassafras tea, whose effects are due to sugar and hot water rather than caffeine.

Among the steeped plant products that do contain caffeine is yerba maté of South America, brewed from leaves of Ilex paraguariensis, one of the hollies. Its caffeine content is the same as ground coffee and about half that of black tea, and its leaves have essential oils that confer a delightful aroma to the brew. An allied species, I. cassine, is native to the southeast coastal region of the United States and was the base of the "black drink" of the Indians of the Carolinas. During the early history of the region, dark tales (all false) were told of witchcraft and orgies practiced by Indians under the influence of the brew.

Each year, Americans drink 35 billion servings of tea, of which 18 billion are iced. One hundred and fifty million pounds are imported from India, Sri Lanka (formerly Ceylon), East Africa, and Taiwan. Our best tea comes from plants grown at altitudes above 3,000 feet, largely in Sri Lanka and the Darjeeling and Assam districts of India. Aside from the green tea served in Chinese and Japanese restaurants, most of our tea is black, made from leaves that are withered and fermented in an oxidation process. The average "cuppa" contains only about half as much caffeine as a cup of coffee. Samuel Johnson notwithstanding, caffeine, is neither addictive nor narcotic.

Many individual fortunes have been made through the years from the tea trade. Glasgow-born Sir Thomas Lipton, for example, financed his perennial efforts to gain for Britain the crown of yachting-the America's Cup—with his profits from tea. As their names indicate, several contemporary American supermarket chains got their start in tea: the Great Atlantic and Pacific Tea Company (A & P), the Grand Union Tea Company, the National Tea Company, and the Union Pacific Tea Company. And tea sets are still the main sales base of fine china-a word that evokes the history of this most social of drinks.

Richard M. Klein teaches botany at the University of Vermont.



Flour Power

Wheat is traded, speculated, stockpiled—yes, even eaten

"And Reuben went in the days of wheat harvest, and found mandrakes in the field, and brought them unto his mother Leah" (Gen. 30:14).

Men have grown wheat as a staple grain from time immemorial. Carbonized kernels found in Iraq are 7,000 years old. In ancient Greece and Rome, wheat flourished. But it is only in more recent times, the era of steam transport, that Triticum vulgare has risen to the status of a world commodity. Shipped everywhere, it has a universal value, like gold or the special drawing rights of the International Monetary Fund. Frequently in short supply, wheat has functioned of late not only as a cash crop but almost as a form of cash per se in transactions between governments. Wheat sold to the Soviet Union in exchange for an abstract quantity called détente was then, in part, stockpiled for subsequent politically inspired transshipments. Wheat sent by us to India for famine relief was held by the Indian government in significant amounts to repay a debt to the USSR.

But just as people in some circles still wear gold rings, so too there are places where wheat continues to be consumed as a foodstuff. In this country, for example, we will produce 2,187 million bushels of wheat between July 1, 1975, and June 30, 1976, according to Department of Agriculture projections. The Department also predicts that we will export between 1,050 and 1,200 million bushels during the same period. In other words, about half of our wheat will stay at home and presumably find its way into our mouths.

The other half (and in past years, the proportion of United States wheat shipped abroad has run as high as 75 percent) flows into what might be called the Eurowheat market as a furtive counter of pure speculative value although no doubt someone will eventually make break or chapati out of it.

With wheat, more than with any other cultivated plant, we can see the perils of mechanized, world-scale agriculture. Extreme centralization has

put the control of wheat distribution into a very few hands. Extreme specialization has encouraged the nonspecialist parts of the world, where grain production is not competitive with the fields of Kansas, to let their grain programs atrophy. The result is a vast potential for manipulation and tyranny, as well as famine. There are, to be sure, other causes for the world's ills. But the extraordinary importance of the United States wheat crop in the scheme of things (especially when our wheat is added to our other grains) is a situation whose worst effects may not yet have been felt.

While there seems to be no simple or even complex cure for the world grain shortage, there is at least a reason for wheat's growing supremacy among grains. Of all the grasses whose seeds yield flour, wheat makes the best white bread and the finest pastries. And in the short history of human food and food technology, there has been a steady development.

in the industrial world, from grain diversity to an almost complete reliance on refined white wheat flour. Health food zealots harangue us ceaselessly about the nutritional perils of such a diet, but the trend is probably irreversible and rests on an almost universal preference that can be best satisfied only with highly processed wheat flour. A long history has led us to this stage.

The earliest human consumption of grain was prehistoric and probably consisted of toasted seeds. Here all grains were equal, but as soon as someone progressed to the next stage of grain cookery—porridge—a hierarchy of grains asserted itself. Oats and buckwheat responded best to simple boiling: rye and wheat make a poor porridge, which can be defined as grain boiled and softened to make a thick soup. Later came flatbread, a primitive and despised form even in biblical times, which depended on the invention of ovens and milling and



changed the selection of preferred grains. It was discovered that wheat and rye produced a tenderer unleavened flatbread than other grains. Finally, once leavening was perfected, risen bread—light, airy, and more easily digestible—took pride of place among grain-bread preparations. This last advance must have taken place before the tribes of Israel crossed the Red Sea.

Yet it took the ensuing millennia for even the most sophisticated societies to convert to an exclusively wheaten loaf. As late as 1764, 12 percent of the grain in English bread was barley, 10 percent oats. This was not because the English liked it that way. Dr. Johnson's definition of oats ("A grain which in England is generally given to horses, but in Scotland supports the people") betrayed a prejudice but did not reflect comestible reality. In 1791, pertinacious Boswell wrote that oats were "the food of the people in Dr. Johnson's own town."

The truth is that England could not produce or buy enough wheat to suit its tastes until about 1825, when agriculture grew efficient enough to obviate the need for supplemental grains hat would grow where wheat would not. Former staples such as spelt, emmer, and buckwheat gradually all

out disappeared.

Eventually, under modern condiions, the competition among bread grains narrowed still further. Only wheat and, to a certain extent, rye stayed in the running, because only hey form the stiff-walled pores characteristic of a light, risen bread. These pores, usually thought of as air toles, remain after a yeast dough is baked. Carbon dioxide from fermenting yeast collects in small bubbles in elastic wheat or rye dough, and bakng solidifies the bubbles into pores.

Because of the special nature of heir protein, wheat and rye possess he elastic quality and the necessary oughness to hold the gas. Wheat proein consists almost entirely of two colloidal substances. Gliadin is elastic. Glutenin is tough. Together they orm gluten. Rye flour contains only gliadin and thus retains less gas. Rye oread, by volume, is from 55.7 to 70.7 percent porous. Wheat bread is 73.0 to 83.0 percent porous. Pure rye

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bread, then, is denser than bread made from wheat.

Rye falls down on other scores. It forms larger pores, and its texture is coarser. The skin of the rye kernel is also thicker, so that it yields less white flour than wheat after milling, 60 instead of 70 percent.

Milling breaks open the kernel and permits the flour manufacturer to sift out most of the grain's nutritive value. The outer "bran" layer—a source of iron, phosphorus, protein, thiamine, and roughage—is most commonly reserved for animal feed, along with the protein-rich but quickly spoiling germ. What remains is the white, starchy endosperm. One hundred pounds of milled, unsifted wheat normally yield 28 pounds of feed and 72 pounds of flour. A centrifuge can further refine white flour into high starch and high protein fractions. The high protein (gluten) flour is bread flour. The high starch, low gluten residue is the pastry chef's cake flour, because his aims are opposite to those of the bread baker. For cake, gluten's elasticity and toughness are an abomination. (Cake flours are also more finely ground than bread flour or all-purpose flour, the compromise between bread and cake flour that is the most widely available flour in supermarkets.)

Some gluten, however, is necessary for a flaky crust, which means that the pastry chef must relax the gluten after mixing and rolling have activated it. This is why delicate doughs must "rest."

The relaxation principle is applied with a vengeance in making puff pastry, the flakiest and most complex of all pastry doughs, which should be made only during the cooler months. By folding a butter-filled dough several times, in several stages, over several hours alternating with long rests, you end up with a pastry that is 730 very thin, butter-separated layers thick. Puff pastry is the height, the acme, the apogee and apex of wheat cookery. It is worth the trouble once in a while. It also freezes brilliantly. And as long as we can still buy flour for eating purposes, we might as well flaunt it, especially during the holiday season. Who knows, next year they may be selling mandrake as a substitute. The wheat, of course, will be stored at Fort Knox.

Raymond Sokolov is a free-lance food writer. His novel, Native Intelligence, was published last spring.

Dartois a la Confiture (Puff Paste Tart with Jam)

3 cups all-purpose flour, approximately

4 cup cake flour

30 tablespoons (15 ounces or 33/4 sticks) chilled butter (unsalted)

teaspoons salt

cup plus 2 tablespoons ice water, approximately

cup apricot jam

egg yolk, lightly beaten

- Stir the all-purpose flour and the cake flour together in a large mixing bowl. Scoop out 1/2 cup of the mixture and reserve.
- 2. Cut 34 stick of butter into small pieces and place in mixing bowl with flour. Cut the butter into the flour with a pastry blender or with two knives. Blend until the dough looks like oatmeal.
- Stir the salt into the ice water. Then pour the water into the dough, and blend with a rubber spatula. Press the dough into a ball with one hand. Use a tiny bit more water if you need it to hold the dough together. Do not overdo on water or you will get a stiff pastry.

4. Press the dough into a more or less rectangular shape. Dust with flour, wrap in waxed paper, and refrigerate for 40 minutes to

relax the gluten.

- 5. Beat the remaining three sticks of chilled unsalted butter into a softened but still cold mass with a rolling pin. Spread the mass with the heel of one hand. Then work in the 1/2 cup of reserved flour mixture. Blend quickly and press into a 5-inch square. While the butter is still cold (that is, immediately), roll the chilled dough on a lightly floured board or marble until it forms a 12-inch circle. Set the butter in the center and fold the edges of the dough over the butter. Press the edges securely together to seal in the butter.
- 6. Beat the dough all over with the rolling pin to make the butter flexible. Roll the dough into a rectangle 16 inches long and 8 inches wide.
- 7. Now you are ready to make the first two turns. This means folding the dough like a business letter, in thirds. Fold the bottom third up. Then fold the top third down over the other two thirds.

- 8. Turn the dough so that the top fold has its open edge to your right (in other words, give the dough rectangle a quarter turn, counterclockwise). Now when you roll the dough into a 16- by 8-inch rectangle, the long edges will be where the short edges formerly were. Fold in thirds as before. Wrap in waxed paper and refrigerate in a plastic bag for 50 minutes.
- 9. Repeat steps 6 to 8. Refrigerate for 11/2 hours.
- 10. Repeat steps 6 to 8. Refrigerate for 2 hours or as much as several days (or freeze if you are working well ahead).
- 11. Roll out dough into a 12- by 20inch rectangle, rolling crosswise and lengthwise. Using an 8-inch cake pan as a template, cut two 8-inch circles in the dough. (Remove excess dough and reserve in a single layer for baking cookies.) Center one of the dough circles topside down on a moistened baking sheet, cover with waxed paper, and refrigerate. Refrigerate the other circle separately, between two sheets of waxed paper.

12. Preheat oven to 450 degrees.

- When dough is chilled and firm, press it on the baking sheet until it is 9 inches in diameter. Spoon the jam onto the center of the dough circle on the pastry sheet. Then paint the periphery of the dough, where there is no jam, with cold water.
- 14. Set the other disk over the jam. Press the edges of the two circles together. Be very careful not to leave any chinks or jam will leak out and burn. Press all around the circumference of the dartois with a fork to consolidate the seal as well as to leave a striated decoration. Chill for 30 minutes.
- 15. Brush top of tart with egg yolk. For further decoration you may cut swirling lines 1/8 inch deep into the top of the tart with a single-edged razor blade.
- Bake for 20 minutes at 450°. Then reduce heat to 400° and continue baking for 25 to 30 minutes or until sides have browned. Slide onto serving platter and serve in wedges while hot.

Yield: 8 servings



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How the Elephant Keeps Its Cool

by Peter Hiley

Poorly equipped for life in the tropics, the world's largest land mammal has evolved some vital—and playful—ways of coping

When Hannibal made his epic journey from Carthage to Italy in the third century B.C., his elephants had to overcome snow and intense cold in crossing the Pyrenees and Alps. Today, too, elephants are often found at the 8,000- to 12,000-foot level on Mount Kenya, East Africa, where it is distinctly cool. Yet elephants are generally associated with tropical habitats, and within 300 miles of Mount Kenya they live in semiarid conditions. How do they manage in these different environments?

Elephants, like all mammals, are homoiotherms, which means they maintain a more or less stable body temperature. For elephants this is about 97°F. To do this, they must balance heat load (heat produced within the body plus heat from the environment) against heat loss. Without this balance, their body temperatures will either rise or fall.

Humans can wear a wide variety of clothing to retain or lose heat, depending on the climate, but other species can alter their heat loss only by behavior, by variations in their hair coats, or by altering the flow of warm blood to the skin. If less warm blood goes to the skin, skin temperature decreases and less heat is lost.

In a cold environment, a large animal's size is of distinct advantage in maintaining the balance between heat production and heat loss. If an object, be it a cardboard box or an elephant, triples in size, its surface area only doubles. Also, in general terms, an animal loses heat in proportion to its surface area, but produces heat in

proportion to its size. In the cold, therefore, the elephant's immense size is of considerable advantage.

In a hot environment, however, the elephant has to lose large amounts of heat, and its relatively small surface area, which was such an advantage to it in the cold, now becomes a liability. Since it was not known how the elephant overcomes its heat problem, David Robertshaw (until recently professor of animal physiology at Nairobi University) and I decided to investigate the animal's thermoregulatory physiology.

In any study of this kind, one must consider both the heat inputs to the animal and its heat output. Heat going to or from the body must obey the physical laws of heat transfer. Heat can be transferred by convection (heat distribution by the moving up of a heated part and the replacement of this by a cooler part), conduction (the passing of heat energy from molecule to molecule through or between substances), or radiation (the transporting of heat by electromagnetic waves). The amount of heat transferred depends on the temperature difference between the body and its environs.

In temperate climates, the body is hotter than the environment and the net transfer of heat will be to the environment. In tropical climates, where environmental temperatures often exceed body temperature, the flow of heat is into an animal.

We studied elephants at Tsavo National Park in Kenya, an area that is largely open bush. Although there are a number of trees and some waterholes, the expanse is mainly dry, dusty grassland. In such regions, as much as 90 percent of the elephant's heat load comes from the environment; the remaining 10 percent is produced within its body through metabolic activity (heat of digestion,

locomotion, and so on). The environmental heat load can be in the form of shortwave radiation from the sun or longwave radiation from the rest of the environment. We found that shortwave radiation—directly from the sun, reflected from particles in the air, or reflected back from the ground—constituted about 43 percent of the elephant's heat load.

In the dusty study area, ground temperature reached 110°F., and the longwave heat from the ground constituted 30 percent of the elephant's heat load. (If the ground is covered with vegetation, the temperature remains lower and the radiant load from it is smaller, but the elephant frequently has to contend with dry, dusty conditions.) Longwave radiation from the rest of the environment made up the remaining component (17 percent) of the elephant's environmental heat load.

How does the elephant lose this heat? When we lie in the sun and get hot, we start to sweat. Thinking that perhaps the elephant does the same, we tried to find out by measuring the water loss from its skin and by examining a skin sample through a microscope to see if it had sweat glands.

Although the temperature varied during the day from about 65° in the early morning to 95° at midday, water loss from the elephant's skin remained constant. For an averagesized elephant, the heat required to evaporate the water lost through the skin would be sufficient to bring to the boil six gallons of water per hour. At midday, evaporation constituted only 7 percent of the elephant's total heat loss. Also, since we found no sweat glands in the elephant's skin, elephants cannot sweat; any water loss we recorded was the result of diffusion through the skin.

The alternative method of evapora-

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tive heat loss is panting. But the elephant's respiration rate was ten to twelve breaths per minute, regardless of the time of day or the temperature. So we also ruled out panting as a way the elephant increases its heat loss.

What about the nonevaporative heat losses? Only the base of the elephant's feet are in contact with the ground, so heat lost by conduction is minimal. In our studies, air temperatures were about 90°F, and the temperature difference between the animal and the air was small. As a result. only 3 percent of the elephant's total heat loss was due to transfer of heat to the air by convection. An object, however, will radiate heat to anything in its environment that is cooler than itself. Plants, for example, are relatively cool objects because transpiration acts as an evaporative cooling process. Thus, heat can radiate away from the elephant to plants and other heat "sinks." This radiant heat loss was found to constitute 80 percent of the elephant's total heat loss.

The remainder of the elephant's heat loss (10 percent) was not dissipated but remained within the body and caused the animal's body temperature to increase during the course of a typical day from 97.0° to 100.8°. This stored heat was then lost to the environment in the cooler evening conditions through conduction, convection, and primarily, radiation.

Since elephants do not sweat and do not pant to lose heat, they have a considerable problem when exposed to a high heat load. Physiologically, they can increase their heat loss only by increasing cutaneous blood flow, thus elevating skin temperature. Because the magnitude of this increase in nonevaporative heat loss will be small, behavior becomes crucial in maintaining the balance of heat loss and load. Unless elephants can decrease their heat load or increase their

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To avoid the midday heat in their East African habitat, elephants stand beneath shade trees, leaving feeding and other activities for the cooler morning and evening hours.

heat loss through behavior, the load at high air temperatures will exceed the loss and their body temperatures will rise. But as in humans, the elephant's tissues, especially those of the brain, can only withstand a limited rise in temperature, about nine degrees, before death occurs.

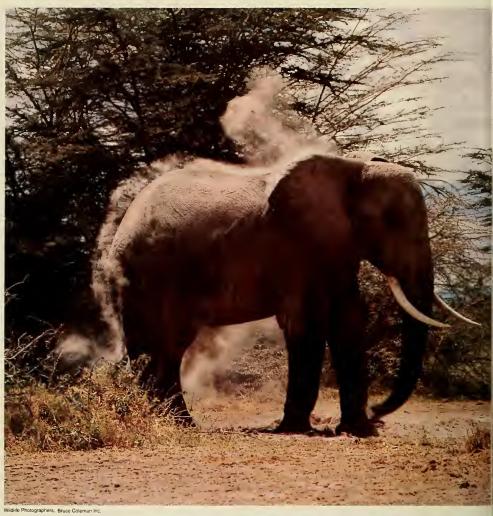
What can elephants do to decrease their heat load? They can stand in the shade, where air and ground temperatures are normally cooler, thereby reducing the longwave radiant heat load and much of the shortwave radiant heat load from the sun. In fact, elephants do seek shade in the hottest part of the day, many of them standing under trees until the temperature drops. At midday, too, elephants decrease their activity, thus minimizing their internal heat production. Most feeding, for example, takes place in the morning and early evening.

The elephant's skin color is not much help. A dark gray object absorbs as much as 85 percent of the radiant energy that falls on it. Elephants, however, frequently cover themselves with dust or mud so that they become the color of the soil in their habitat. Since many of these soil colors absorb less, or reflect more, radiation than the elephant's skin color, this will decrease the heat load.

Elephants can also lose heat through their behavior. In his Natural History, Pliny the Elder observed that "elephants are especially fond of water and wander much about streams... and squirt water on themselves." Present-day observers, too, report that elephants frequently wallow in the wild. By covering or spraying themselves with water, they lose heat through evaporation and conduction. On very hot days elephants will even draw up water from their stomachs through their trunks and then spray themselves.

According to many earlier studies, as well as to folklore, elephants flap their ears to keep cool, increasing the rate as air temperature rises. Studies have also shown that the blood leaving the ear is significantly cooler than that entering it, which suggests that the ear functions in a way similar to an automobile radiator.

Our studies, however, did not confirm this. To lose heat, the ear surface—like the rest of the body—has to be hotter than its environment or



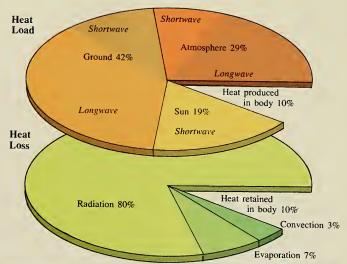
water has to evaporate from it. We found that the ear's skin temperature at midday was cooler than that of the rest of the body and its environment, especially the back of the ear where there are prominent blood vessels. In addition, water loss from the ear was not significantly greater than that from the rest of the body and there were no sweat glands in the skin of the ear. At the hottest part of the day, therefore, the elephant was not using its ears as a cooling mechanism.

By 6:00 P.M., however, the blood vessels in the ear were dilated, the

blood flow through the ears had increased, and the temperature of the ears was higher than that of the general body surface and the environment. Thus, in the evening, the ears do function as "radiators" of heat to the cooler air.

Nevertheless, even during the day some heat was being lost from the ear, and in this respect the flapping of the ears would increase the small convective component of this loss. As a result, the blood draining from the ear could have been cooled slightly; possibly this also cools the blood going to the brain. In many ruminants there is a special heat-exchange mechanism between the veins containing cool blood from the nasal passages and the arteries that go to the brain. Since this cools the blood going to the brain, the temperature of the sensitive brain tissues can remain low, even though body temperature may rise by as much as twelve degrees. This mechanism is especially well developed in the oryx, which inhabits hot, arid environments.

In hot conditions elephants also specifically spray their ears with



An elephant's dark gray skin color is highly absorbent, but by covering itself with dust, the animal is able to reflect more heat. The seeming antic of squirting its body with mud, below, is another effective way of losing heat.



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Water, not just for drinking but also for cooling off, is vital to the elephant. In many regions, however, crowded populations face dry conditions as they overgraze the land, causing erosion and water runoff.

water. At such times, the ear's large blood vessels make it especially useful as a heat loss mechanism.

Having evolved these behavioral patterns, the elephant is able to regulate its heat input and output and keep its body temperature within tolerable limits. But the elephant is sometimes found in areas where there is little tree cover or surface water, therefore restricting its behavioral options. How does it manage? Although no one has yet studied thermoregulation under such conditions, the animal would probably suffer great stress, which if severe enough, would adversely affect its survival.

This subject becomes of greater importance as the elephant's habitat increasingly deteriorates. A growing human population and a shift to subsistence agriculture and livestock farming have resulted in a drastic decrease in the area available to the elephant. The animal's major problem is overcrowding, particularly in the national parks. In Murchison Falls National Park in Uganda, for example, wooded areas are changing to grass as elephants run out of available forage and start to strip bark off trees and eat saplings. Without tree cover, the land begins to erode; rainwater, instead of soaking in, runs off, taking with it soil and small plants. This is happening in Tsavo National Park, where grassland is changing to semidesert. Consequently the shade and surface water that are vital to the elephant's survival are disappearing.

By recording body temperatures and analyzing skin samples, we are studying more than the elephant's physiology. We are learning how the elephant relates to its environment, and such knowledge must be the basis of any program to preserve this spectacular animal.





The Sorrow and Spirit of Six Bells

From one day to the next, life in the Welsh coalfields brings danger, death, and small joys

by Tom Oakley

Abertillery is a small industrial community tucked away in a valley in Gwent (known until a short time ago as Monmouthshire County), South Wales. The area is no longer endowed with its former natural beauty, and wealth, to any great extent, has escaped the people.

The community owes its existence to the seams of coal underlying it. At Abertillery, coal began to be mined during the middle of the last century to feed the steam-driven machines and furnaces that had come to life with the Industrial Revolution. At about the time that Americans were rushing to California to search for their fortunes in gold, British workers were going to Abertillery, and many other towns like it, to labor in the mines for what they also hoped would be their fortunes.

Traveling to Gwent from the Forest of Dean in Gloucestershire, from Herefordshire, Somerset, Devon, and Cornwall, this assortment of people developed into a hardworking, friendly lot—adaptable, tough without being unfeeling, and proud of their communities and way of life. But little did these men who moved to South Wales know that all they would get would be more pain and poverty than any they were leaving behind. Digging

for coal was dirty, backbreaking, dangerous work—and it still is.

Six Bells is just one small but typical part of Abertillery. It has a coal pit, a few chapels, a church, a couple of pubs, a club or two, houses shoulder to shoulder—set back to back in rows away from the pithead—and, in times of trouble, an unbreakable community spirit.

The strength of this spirit was demonstrated one summer day in June 1960. The morning shift had gone off to work just after dawn, not singing Cwm Rhondda or Calon Lan or one of those other Welsh hymns in perfect harmony, as some Hollywood directors would have us believe. These were normal minerssleepy-eyed and wishing they could stay out under the blue sky and shining sun. But it was not to be. About four hours later, forty-five of them died in the squalor, filth, and darkness of Six Bells pit, when a spark accidentally ignited a pocket of methane. All those within striking distance of the flame that flashed through that part of the workings were dead in an instant; one was just eighteen years old.

Most of the dead were from Abertillery, many were from Six Bells. Four or five of the men had lived on one street. For weeks after.

Photographs by Paul S. Conklin







Six Bells mourned its dead. Hundreds of people followed the coffins up the hill and stood bareheaded at the cemetery on the mountainside overlooking the valley.

But most of all, the people rallied to the families left behind—the fatherless children and the widows. It was not the money that mattered so much; it was the much-needed understanding and sympathy and, most of all, the practical help, the community spirit. Those families hit by the blast that ripped through the tunnels that June day and snuffed out forty-five lives must have been helped by the feeling that they were not alone in their loss; everyone had lost a friend, a relation, or maybe someone they just knew.

The colliery stayed quiet for a few days; then it was back to work, back to the coal face and the squalor, back to the danger.

In the mines, danger is always present. There was a period in the 1950s, when roof falls in the tunnels occurred with monotonous and fatal regularity. In one such disaster, one man crawled under sagging rocks to rescue a colleague who had been buried when the roof collapsed. He reached the man and pulled him out, but the effort had been in vain for the man was dead. A week later the rescuer was also dead, the life crushed out of him by rocks and debris from a coal face roof.

Miners have never had a very high standing in British society. One attitude is, "After all, any fool can shovel coal." The picture of the miner of yesteryear bathing in front of the brightly burning fire in the kitchen of his small cottage, the water having been heated in huge saucepans and kettles on the open fire, caused many a snigger.

This daily bathing ritual was performed in hastily built houses that the companies rented to the influx of miners. These houses, erected in rows of up to forty, were as near the pit top as possible. They had a kitchen and one other room on the ground floor and two or perhaps three bedrooms upstairs. In some of the houses the staircases entered one of the bedrooms, and entry to the second bedroom was gained through the first. All the rooms were as small as possible, and it is difficult to understand how the large families of the early 1900s managed to exist in them. The front door opened

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directly onto the street, and more often than not a back door opened into a garden with an outhouse at the end of it.

In the old days, the "front room" usually contained a piano or harmonium and many a good time was had by all singing on a Sunday night after chapel. Those who did not go to chapel also had a good time: they went to the club and consumed pints of beer—and they still do.

Chapelgoers and clubgoers had one common bond—they all sang, usually the same songs. But those in the club sang with a different sort of gusto when accompanied by a pianist who had drunk six or seven pints of beer. Welshmen are renowned for their group

beer. Welshmen are renowned for their group singing. Put six Welshmen together and they will sing at the drop of a hat, anywhere. And a pound to a penny it will be a hymn tune. The miner's sport is Rugby (football) and

at a big game his love for it comes out in the form of singing. The game is treated like a religion in many parts of South Wales, and to be chosen to play for Wales against England, Scotland, or Ireland, in that order, is akin to being guaranteed a place in heaven.

A few nonenthusiasts ridicule the importance placed on Rugby, but a visit to the national stadium in Cardiff for a game against one of the three other international teams is something to behold and to hear. For about an hour before the start of the match, the fans sing, and it is said that many a Welshman has been reduced to tears by the atmosphere of those memorable minutes.

At the national stadium on an international day there are between fifty and sixty thousand Welshmen all waiting to see fifteen of their Rugby heroes run out on the field and beat the daylights out of the English, Scots, or Irish—the opponent does not really matter as long as the defeat is sound enough. The Welsh want to sing for their heroes. And sing they do. The sound swelling from their throats makes the hair on the back of your neck stand up.

Singing is a good, cheap form of entertainment. A good singsong, especially with some of the catchy old tunes, does wonders for spirits made low by the few possibilities of life. And during the dreary days of the 1930s, when the depression was biting its hardest at the people of Abertillery, a town hit as badly

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as any in South Wales, anything that kept morale from completely dying was vital.

Men walked the mountainsides to occupy the jobless days. They gathered on street corners to talk, wish, hope, and sing. It was from this time of economic disaster that some of the choirs grew, and to this day, they remain one of the great Welsh pastimes.

Work came eventually but at a very high price-war. Many of the men returned to the mines and their dangers; others donned uniforms and marched off to war. In both cases lives were cut pitifully short. The only dif-

ference was that the names of the war dead

were chiseled on a war memorial erected just

they had left behind.

outside the town. With peace came a change in mining and in expectations. The men returning from war had changed. Men who had fought in the deserts of North Africa, in Europe from Normandy to the Rhine, and in the jungles of Burma wanted something better than what

Suddenly they realized that some of the little dwellings were not homes at all; they were nothing more than hovels. These structures were destroyed—a justly deserved fate—but many were then rebuilt to house families comfortably. Of the others, there are just remnants-and memories of a long love-hate rela-

tionship.

The old wooden pitprops of the mines also vanished. And so did the old miner, with his multitude of blue scars caused by wounds left uncleaned because time meant coal; coal a little more money; and money, food for a family. Into the pits came self-advancing hydraulic supports and coal cutters, which automatically load the coal onto a conveyor. The miner became a changed man. Gone were the pick and shovel and the other instruments of industrial torture.

But danger still lurks in the dark passages. The tall cylindrical ambulance boxes still dot the workings. And sturdy first-aid men are always ready to go to the assistance of an injured workmate and administer morphine to the badly hurt. The drug is kept locked in the boxes.

One often related incident that took place at Six Bells colliery exemplifies the dangers. An ambulanceman, answering a shout in the darkness, found a workman with his foot trapped in a chain being dragged relentlessly toward the whirling blades of a coal cutter and certain death. The ambulanceman grabbed a razor-sharp ax and walked alongside the man while efforts were made to stop the machine and free the man's foot. In the minds of those present, there was no doubt of the outcome should efforts to stop the coal cutter not succeed. The machine was stopped but not before the workman lost some of his toes.

The coal cutters also brought black lung disease because the dust they created in the tunnels was breathed in by the men, year after year. Now, water is pumped into the tunnels to keep the dust down while coal is being cut, but the effects of black lung can still be seen today as old men, their shoulders hunched for-

ward, gasp for breath.

Aboveground, too, there were changes. The tragedy at the mining village of Aberfan, where more than a hundred children died when a slide of pit waste stacked high on the mountainside buried their school, brought changes to the valleys of South Wales. People suddenly realized that the huge heaps of slag disgorged by the pits were dangerous as well as ugly. But years before they had been told by one politician: "You can't eat scenery."

Government-backed schemes were quickly drawn up to get rid of the lethal eyesores. "Reclamation" became as fashionable a word as "pollution," even though these waste piles had been a blot on the landscape for as long

as there had been pits.

One pile at Six Bells was flattened to make room for a factory; a recreation center with a swimming pool was built on another pile in Abertillery. The biggest scheme, however, is in Cwmtillery, at the head of a small valley cutting off the main part of Abertillery. The valley is being partly filled in to provide much needed flatland. Now, earthmoving machines crawl over the side of a waste pile there like giant insects smoothing and flattening it.

The face of Abertillery is changing and there are hopes that some of the area's beauty will return. But for all those hopes, it can never return to the little green valley dotted with small farms that it was a century ago, before someone lifted the lid on that Pandora's box and revealed all the coal, and the pain, suffering, happiness, and joy that became Abertillery.





The designation "army ants" is a fitting analogy for insects that carry out attacks in large groups, move over the terrain in well-organized columns, and periodically change their camps. Ever since the eighteenth-century British explorer Henry Smeathman first recorded the activities of army ants, naturalists have been particularly struck by certain similarities between these ants and human combatants; practically all reports of army ant behavior have included vivid military metaphors.

Consider, for example, this description of army ants by A. Hyatt Verill, an explorer of animal life in South America: "The army ants of the tropies are most remarkable in many ways. Utterly blind, yet they move in vast armies across the land, overcoming every obstacle other than fire and water, maintaining perfect formation, moving with military precision and like a real army having their scouts, their engineering corps and their fighting soldiers."

Although such accounts are some-

what overdrawn, the spectacular activities of army ants in the tropics are one reason these insects have fascinated so many generations of scientists. But this is 1975, and the rationale for studying these ants has changed from one of simple curiosity to one of considerable scientific significance: an understanding of the development and evolution of animal societies.

By almost every criterion imaginable, human societies are organized through some of the most complex biological, psychological, and cultural processes that exist in the animal world. Nevertheless, complex patterns of social behavior have also evolved many times in different evolutionary lineages of invertebrates, especially among the insects. Permanent societies exist in termites and in many species of bees and wasps, but invertebrate social behavior has evolved to its greatest degree of complexity among the approximately 6,000 species of ants that comprise the insect family Formicidae.

In this family is a group of species popularly known as army ants. These ants make up the subfamily Dorylinae (from the Greek word dory, meaning "spear," which probably alludes to the ants' potent sting). There are about 170 species of Dorylinae in the Western Hemisphere and approximately 100 additional species inhabit Africa, Asia, Indo-Malaysia, and Australia. The majority of doryline species in both hemispheres of the world are most abundant in the warm. moist climates of tropical regions, and this distribution suggests that the tropics was the site of their evolutionary origin. Many species, however, have evolved adaptations for living in more temperate climates. The United States has about fifteen species, all occurring in the southern and midcentral parts of the country.

Most species of army ants are subterranean; consequently the bulk of our information about army ant biology and behavior stems from research conducted on those atypical species that conduct a substantial portion of their activities on the surface of the ground—the epigeal species.

Colonies of these species typically consist of a single queen, a brood of developing young, and a large population of adult workers. The queen is the sole reproductive agent in the colony. In most species she is at least twice as long as the largest workersand much stouter. The bulk of her weight is concentrated in her abdomen, the site of her immense reproductive capacity. At regular intervals, her abdomen swells with fatty tissues and eggs as she enters the gravid state. At this time the queen may lay from 10,000 to 100,000 eggs, depending upon the species. The queen insures colony survival not only by periodically producing new



broods but also by secreting chemical substances that attract the workers and thereby facilitate colony unity.

The brood passes through four successive stages of development: embryo, larva, pupa, and finally, the adult ant, which on emergence from the pupal stage is lightly pigmented, soft bodied, and readily recognizable as a callow worker. The brood and adult worker populations consist of females with underdeveloped ovaries; consequently all are sterile. In most species, the workers developing from a given batch of eggs vary in size and structure, a condition known as polymorphism.

Adult ants that differ greatly in size and structure often exhibit contrasting patterns of behavior in their societies, so that a division of labor is established within the colony. For example, in *Eciton hamatum* from Central and South America, the smallest

Worker ants, left, attend an Eciton hamatum queen that is swollen with eggs and fatty tissues. They groom her and place all her eggs in a pile. Inside a nest of Neivamyrmex nigrescens army ants, below, workers groom the colony's pupal brood prior to their emergence as immature adults.

workers (approximately 3 millimeters in length) spend most of their time in the nest feeding the larval brood. Intermediate-sized workers, which constitute most of the colony's population, participate predominantly in raiding. The largest individuals (13 millimeters in length) have huge heads and long, powerful jaws. If these major workers become aroused during a predatory raid, they

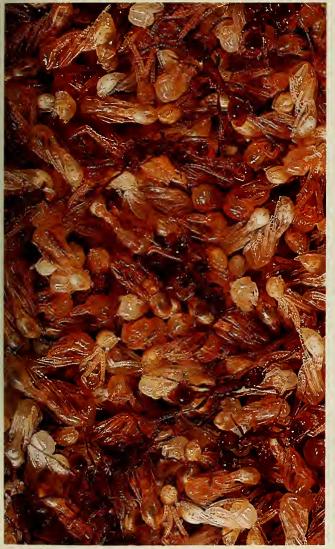
assume a characteristic position in which they rear upward with their front legs off the ground, vibrate their antennae, and rhythmically open and close their pincerlike jaws. These ants are popularly called soldiers. The analogy is a good one because this behavior undoubtedly affords the colony protection against predators. The soldiers not only look formidable, they are. Their huge heads have an enormous musculature that operates their extremely sharp mandibles. The tips of the mandibles curve backward and are difficult to remove once they penetrate the skin.

The epigeal species of army ants possess some truly outstanding characteristics. First, they have large colonies. Species containing the fewest individuals belong to the genera Neivamyrmex and Aenictus, which have colonies containing approximately 100,000 individuals. Eciton burchelli of tropical America may contain well over 500,000 workers, and estimates of colony size for some species of the African genus Dorylus range as high as 30 million individuals. The large size of army ant colonies makes for very impressive feeding habits. Edward Step, a science writer who made a career of describing the marvels of insect life, depicted army ants as a terror to all other creatures.

"They march in such enormous numbers that everything which desires not to be eaten has to fly before them; from the cockroach and the mouse to the huge python, the elephant, the gorilla, and the warlike native man, the story is the same."

Let's set the record straight. Although some species occasionally eat small vertebrates, such as lizards and snakes, their typical diet consists of other species of arthropods, especially insects. *Eciton hamatum*, for example, feeds primarily on immature stages of social wasps and nondoryline ants.

A second characteristic of *E. hamatum* and *E. burchelli* is the nature of their nests. Colonies of most ant species excavate tunnels and chambers in the soil or settle into preformed cavities in trees. Regardless of whether the nest is fabricated, dug, or even taken over from other insects, the same nest generally serves as the colony's shelter throughout its life. These species of *Eciton*, by contrast,





do not have permanent nests; their nests are formed by thousands of ants clustering together and interlocking their legs. At the start of nest formation, the ants form small, stringlike strands, which dangle from beneath a raised object such as a fallen log. As other ants reach these primary clusters, they run downward along the hanging strands, and by fastening themselves to other ants, extend the strands toward the ground. As additional ants stream into the forming nest, the strands become ropes, and the ropes eventually fuse into a heavy fabric of ants.

A third characteristic that typifies

army ant behavior is the degree to which they conduct all of their raiding activities in cohesive, organized groups. All activities taking place outside the nest are conducted by columns of individuals closely following a chemical trail that is deposited continuously by each worker ant as she runs along the ground. Because army ants lack the well-developed compound eyes found in other ant species, they are particularly dependent on these odor trails for the success of their large-scale predatory raids.

Perhaps the most striking behavior of the epigeal species is their periodic shifting of nesting sites. These movements, or emigrations, involve the entire colony—the workers, brood, and queen. The new nest may be 100 meters or more from the old site and it may take a colony several hours to complete the move. During the last century, practically all reports by naturalists of army ant behavior included reference to this peculiar pattern of migratory behavior.

The first truly systematic investigation of this phenomenon was conducted by the late T.C. Schneirla, curator of the Department of Animal Behavior at The American Museum of Natural History. By the end of his first field trip to the American tropics.



E. hamatum army ants dismember a katydid, left, for transport back to their nest. Protected by a hard exoskeleton and a chemical secretion, a predacious carabid beetle, below, consumes the larvae of N. nigrescens ants. The beetles also rob ants of captured prey.

into a network of smaller branches. By mid-morning the raiding columns of ants may cover an area extending up to 100 meters from the nest. Army ants at the front of the raiding column attack insects and other arthropods, biting and stinging the prey, pulling it apart, and carrying it back to the nest. The raiding column is therefore a two-way stream, with some ants advancing from the nest and others returning with their booty. As evening approaches, the raid turns into an



Schneirla had gathered enough evidence to show that the emigrations of both species of *Eciton* did not occur sporadically. Instead they took place at predictable intervals.

After observing the same colonies of *Eciton* for some months, Schneirla discovered that the colonies actually exhibit cycles of activity and that each cycle can be divided into two phases. The first is the nomadic phase, during which a large proportion of the adult worker population engages in daily predatory raids that begin at dawn. Ants pour out of the nest and form several long columns; each column subsequently divides



emigration, with the entire colony workers, brood, and queen—moving over one of the principal raiding trails of that day.

This daily routine of massive raids, followed by emigrations to new nesting sites, continues for approximately two and a half weeks. Then, more or less abruptly, the colony settles down to a much less active phase, the statary phase, which lasts for about three weeks. During this period, the daily raids are much less intense than during the nomadic phase and relatively little prey is taken back to the nest. Throughout the statary phase, the colony does not emigrate, but remains at the same site for the entire three-week interval.

In addition to finding that emigrations of E. hamatum and E. burchelli occur only during one phase of each behavioral cycle, Schneirla also noted a very significant correlation between the behavioral phase of each colony and the developmental stage of its immense brood. Whenever a colony was found to be nomadic, the brood being transported to the new nest by the adult workers was always in the larval stage of development. When emigrations ceased and the colony entered into the statary phase, Schneirla found that the broods consisted only of individuals in the pupal stage of development. Furthermore, whenever a colony was observed throughout the transition from the nomadic phase to the statary phase, the behavioral transition always coincided with the period when mature larvae were spinning cocoons and entering the inactive pupal stage.

This correlation between colony behavior and brood development eventually enabled Schneirla to formulate the theory that the behavioral

To escape marauding army ants in southern Arizona, these relatives of carpenter ants (genus Camponotus) climb grass stems with their larvae and pupae. This behavior succeeds because army ants of this region do not climb. In the

tropics, E. burchelli ants

readily climb for prey.

phases of these species of army ants were regulated, not by events in the ants' external environment, but by interactions occurring inside the colony, especially between the adult workers and the developing brood. For example, each new nomadic phase begins within twenty-four hours after the pupal brood has completed its development and eclosed (emerged from the pupal cases) into immature callow workers. Because these two events occur together so regularly, Schneirla postulated that the increased activity of the adult ants might be caused by chemical secretions (pheromones) emanating from the callows.

Studies that my graduate student John Mirenda and I have conducted with army ants in laboratory nests clearly show that eclosion is indeed a period of greatly increased activity in the nest. The adult ants eagerly rip off the pupal skins that tightly encapsulate the callows, in a frantic effort to lap up the moist secretions that bathe them. As soon as most of the callows have eclosed, the adult ants embark on a large-scale raid, with most of the booty being consumed by the callows.

Callow army ants behave very much like callows of nondoryline species in that they do not forage along with the adults until they have matured within the nest for approximately one week. Because the vast majority of nondoryline species are sedentary and do not change nesting sites, the behavior of their callows poses no unusual problem for such colonies. But army ants are nomadic, and to make matters worse, the first emigration of each new nomadic phase takes place on the first night after the callows eclose. For the colony to remain intact, the callows must leave the nest and run the entire length of the emigration route along with the mature adult workers.

The absence of callow army ants from raiding columns and their emergence from the bivouac at the start of an emigration represent a curious inconsistency. However, from the evolutionary standpoint of the adaptive value of the callows' behavior to the colony, their absence from raiding is not at all surprising. The callows are very sluggish and seem to be less coordinated than older workers. If a

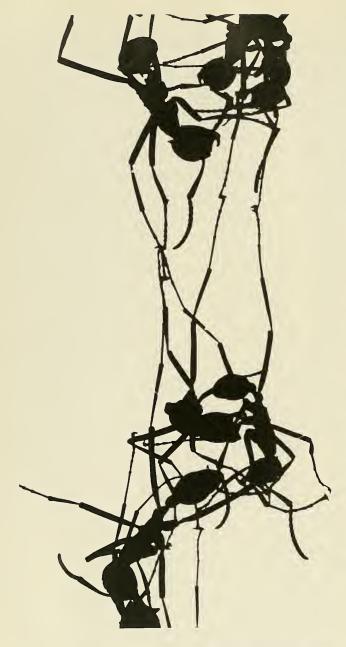
group of callows is removed from the bivouac and placed in the midst of a raiding column, they not only show signs of disorientation but they actually interfere with the rapidly moving adult ants. Because newly eclosed callows remain in the nest during raiding and emerge only at the start of an emigration, their behavior is undoubtedly beneficial to the entire colony. Knowledge of the actual mechanisms and processes that were altered by natural selection to keep callow army ants in the nest during raiding and to enable them to leave the nest at the start of an emigration would greatly increase our understanding of army ant social organization.

We began looking for the answers by studying the trail-following ability of the callows. Laboratory experiments we conducted verified that dayold callows were able to follow the chemical trail of their colony as well as mature workers.

Once we were convinced that the absence of callows from raiding columns was not due to their inability to follow the chemical trail of their colony, we studied the events surrounding the emergence of callows from the nest at the start of an emigration. Our research was done at The American Museum of Natural History's Southwestern Research Station in southern Arizona, and our subject species of army ant was Neivamyrmex nigrescens. The behavior of this species is very much like that of Eciton species; N. nigrescens also exhibits distinct cycles of alternating nomadic and statary phases. It differs from Eciton, however, because the raids, as well as the emigrations, take place at night.

On the evening of the first nomadic day, raiding begins at about dusk. At the start of raiding most of the ant traffic is outbound, a pattern that continues until sources of food are located. From then on, the traffic shifts into a bidirectional mode, as nestbound ants return with their booty. The raid continues at a high pitch for several hours; then, somewhat abruptly, the golden yellow callows begin streaming from the nest and slowly make their way along the trail to the new nesting site.

By observing colonies of *N. nigre-scens* from the start of raiding at dusk, through the end of the emigration



By interlocking legs while dangling from a raised object, E. hamatum army ants begin forming a nest. Additional ants join such strands, creating ropes that fuse into the living fabric of a completed nest. after midnight, we noted two interesting items. First, by the time the callows emerged from the nest, the vast majority of adult workers were already at the new nesting site and were using it as a base for raiding. Second, the emigration column was composed almost entirely of callows, with rela-

tively few adults interspersed in the procession.

These two findings enabled us to suggest several hypotheses to account for the callows' behavior. The first is that the callows are attracted to chemical stimuli emitted by the older adult ants. As the adult population gradually evacuates the nest, the concentration of attractive chemical stimuli decreases inside the nest and steadily increases outside. Thus, the callows may leave the nest simply by following the stimuli emanating from the adult workers.

On the other hand, the adults might play a much more active role in influencing the behavior of the callows. It is well known from the work of E. O. Wilson and Bert Hölldobler of Harvard University that adult workers of many species of ants exhibit specific patterns of behavior for recruiting nestmates to sources of food located at some distance from the nest. Perhaps when foraging adult army ants locate a suitable site for the establishment of a bivouac, they return to the nest and actively arouse the callows. Once aroused sufficiently to leave the nest, the callows may then simply follow the chemical trail to the new location.

Returning to the laboratory, we conducted further experiments that demonstrated that the behavior of the callows was greatly influenced by the social setting provided by mature adult ants. In our experimental enclosures, callows tended to remain inactive by clustering tightly together into a compact ball. When adult ants were allowed to enter the callows' chamber, they actively recruited the callows by literally "plowing" through the ball and breaking it up. Our experiments showed that the key modality in this recruitment is not chemical; it is tactile, the result of repeated bumping of the callows by the older ants.

The picture that emerges from these and other experiments is that callow army ants will be attracted to a wide variety of chemical stimuli, but they will approach the source of the stimulation only when they are aroused sufficiently by their older sister ants. Inside the colony nest many of these stimuli are undoubtedly present in great concentration, not the least of which is a chemical trail that extends from inside the nest all the way to the next potential nesting site, many meters away.

Although these stimuli are present

throughout the evening's raid, the callows do not emerge from the nest until the emigration begins. By observing these emigrations in laboratory nests, we were able to see that only after a new nesting site has been located do the adult ants break up clusters of callows and activate them sufficiently to leave the nest and run along the emigration trail.

When the callows complete the emigration route and enter into the new nest, they immediately regroup and once again become inactive. These clusters can form in the new nest around anything that is inactive, such as stationary callows and mature adults or packets of brood and booty.

Although the successful functioning of an insect society as complex as army ants undoubtedly hinges on numerous interactions among the workers, brood, and queen, my research during the past few years has focused primarily upon the communicative processes between the newly eclosed callows and their mature adult sister ants. This emphasis is designed to illustrate that in insects, as in vertebrate species, immature individuals do not immediately exhibit many patterns of adult behavior; on their route to adulthood the young must mature and gain experience in interacting with all other members of their family group.

Another reason is that the callows constitute a subpopulation that is vital for the successful functioning of an army ant colony in its ecological community. The huge numbers and potent weapons of army ants have made them virtually immune to all vertebrate predators. In tropical habitats, even anteaters have learned not to tamper with the dorylines; instead, they confine their foraging activities to the much more vulnerable termites. In spite of this, the mortality in a colony of army ants is quite high, largely because hundreds of ants are killed each day during the fighting that takes place between army ants and the nondoryline species upon which they prey. The callows represent a new generation of potential raiders, and their behavioral integration into the colony is essential for the colony to continually maintain a critical striking force. Because the normal sequence of the behavioral development of callows is inextricably dependent on the ability of the callows and their older sisters to communicate. we can safely conclude that no generation gap exists among army ants.

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A Cosmic Calendar

Milestones in the history of the universe can be compressed into a comprehensible human time scale

The world is very old and human beings are very young. Significant events in our personal lives are measured in years or less, our lifetimes in decades, our family histories in centuries, and all of recorded history in millennia. But we have been preceded by an awesome vista of time, extending for prodigious periods into the past, about which we know little-both because of the absence of written records and because of our difficulty in grasping the immensity of the periods involved. Yet we are able to date events in the remote past. Geological stratification and radioactive dating provide information on archeological, paleontological, and geological events; and astrophysical theory provides data on the ages of planetary surfaces, stars, and our galaxy, as well as an estimate of the time that has elapsed since that extraordinary event called the Big Bang: an explosion that involved all of the matter and energy in the present universe. The Big Bang may have been the beginning of the universe or it may have been a discontinuous event in which information about the earlier history of the universe was destroyed. But it is certainly the earliest event we can

The most instructive way 1 know with which to express this cosmic chronology is to imagine the 15-billion-year lifetime of the universe (or at least its present incarnation since the Big Bang) compressed into the span of a single year. Then every billion years of earth history corre-

sponds to about 24 days of our cosmic year, and one second of that year corresponds to 475 real revolutions of the earth about the sun. I have presented this cosmic chronology in three forms: a list of some representative pre-December dates, a calendar for the month of December, and a closer look at the late evening of New Year's Eve. On this scale, the events of our history books-even books that make a significant effort to deparochialize the present-are so compressed that it is necessary to give a second-by-second recounting of the last seconds of the cosmic year. And even then we find events listed as contemporary that we have been taught to consider as widely separated in time. In the history of life, an equally rich tapestry must have been woven in other periods, for example, between 10:02 and 10:03 in the morning of April 6 or September 16. But we have detailed records for only the very end of the cosmic year.

The chronology here listed corresponds to the best present evidence, but some of this evidence is rather shaky. No one would be astounded, for example, if it turns out that plants colonized the land in the Ordovician rather than the Silurian Period or that segmented worms appeared only in the Cambrian and not in the late Precambrian. Also, in the historical chronology of the last ten seconds of the cosmic year, it was obviously impossible to include all significant historical events. I hope I may be excused for not having explicitly mentioned advances in art, music, and literature or the historically significant American, French, Russian, and Chinese revolutions.

The construction of such tables and

calendars is inevitably humbling. It is

70

arresting to find that in such a cosmic year the earth does not condense out of interstellar matter until early Sepember; that dinosaurs emerge on Christmas Eve, flowers arise on December 28, and men and women orignate at 10:30 P.M. on New Year's Eve. All of recorded history occupies the last ten seconds of December 31, and the time from the waning of the Middle Ages to the present occupies little more than one second. But because we have arranged it that way, the first cosmic year is ending about now. And despite the insignificance of the instant we have so far occupied in cosmic time, it is clear that what happens on or near the earth at the beginning of the second cosmic year will depend on the scientific wisdom and the sensitivity of mankind.

Carl Sagan teaches astronomy and is director of the Laboratory for Planetary Studies at Cornell University.

Pre-December Dates

January 1 Big Bang May 1 Origin of Milky Way galaxy

September 9 Origin of solar system

September 14 Formation of oldest rocks on moon September 25 (approx.)

Origin of life on earth October 2 Formation of

oldest rocks on earth

October 9 Date of oldest

fossils (bacteria and blue-green algae)

November 12 Date of oldest fossil photosynthetic plants November 15 Eucaryotes

(first cells with nuclei) begin to flourish (Continued)

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December

	Significant oxygen atmosphere begins to develop on earth.	2	3	4	5 Extensive vulcanism and channel formation on Mars.	6
7	8	9	10	11	12	13
14	15	16 First worms.	Precambrian Era ends. Paleozoic Era and Cambrian Period begin. Invertebrates flourish.	18 First oceanic plankton. Trilobites flourish.	19 Ordovician Period. First fish. First vertebrates.	20 Sulurian Period. First vascular plants. Plants begin colonization of land.
21 Devonian Period begins. First insects. Animals begin colonization of land.	Pirst amphibians. First winged insects.	23 Carboniferous Period. First trees. First reptiles.	Permian Period begins. First dinosaurs.	Paleozoic Era ends. Mesozoic Era begins. First corals.	26 Triassic Period. First mammals.	27 Jurassic Period. First birds.
28 Cretaceous Period. First flowers. Dinosaurs become extinct.	Mesozoic Era ends. Cenozoic Era and Tertiary Period begin. First cetaceans. First primates.	30 First hominoids. Giant mammals flourish.	Quaternary Period (Pleistocene and Holocene Epochs). First humans.			

te evening, cember 31

0 P.M. First humans

- 0 Widespread use of stone tools
- 6 Domestication of fire by Peking
- 6 Beginning of most recent glacial riod
- 8 Seafarers settle Australia
- 9 Extensive cave paintings
- 9:20 Invention of agriculture
- 9:35 Neolithic civilization, ies
- 9:50 First dynasties in Sumer and ypt, development of astronomy
- 9:51 Invention of the alphabet, Akdian empire
- 9:52 Hammurabic legal code in abylon, Middle Kingdom in Egypt
- 9:53 Bronze metallurgy, Mycenan culture, Trojan War, Olmec culre: invention of the compass
- 9:54 Iron metallurgy, first Assyrian pire, kingdom of Israel, founding of ırthage
- 9:55 Asokan India, Ch'in dynasty ina, Periclean Athens
- 9:56 Euclidean geometry, Archiedean physics, Ptolemaic astronomy, oman Empire, birth of Christ
- 9:57 Zero and decimals invented in dian arithmetic, Rome falls, Muslim nquests
- 9:58 Mayan civilization, Sung dysty in China, Byzantine Empire, ongol invasion, Crusades
- 9:59 Renaissance yages of discovery, emergence of e experimental method in science

rst second, w Year's Day

idespread development of science and chnology, emergence of a global cule, first steps in planetary exploration d the search for extra-terrestrial inligence



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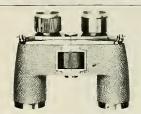
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Drugs, Chants, and Magic Mushrooms

MARIA SABINA AND HER MAZATEC MUSHROOM VELADA, by R. Gordon Wasson, George and Florence Cowan, and Willard Rhodes. With four separately boxed cassettes and musical score. Harcourt Brace Jovanovich, \$82.50; 282 pp., illus.

Ordinarily, one would hesitate to review in a popular journal such as Natural History a work, however meritorious, whose price places it beyond the reach of the average reader. But R. Gordon Wasson, the principal author of what is certainly the most exhaustive treatment yet of an American Indian shamanic performance, is a special case. A selftrained ethnomycologist, this former banker has done more in the last twenty years to put the study of the ritual use of hallucinogenic mushrooms, both past and present, on a scientifically sound interdisciplinary footing than any of a hundred specialists with academic respectability but more narrowly focused interests. He has also been a key figure in the investigation of other plant hallucinogens that have played a major role in Mexican Indian ritual from pre-Hispanic times to the present. Moreover, Wasson's earlier magnum opus, Soma: Divine Mushroom of Immortality (1968), originally issued at an even higher price than his latest work, was subsequently made available in a popularly priced, unabridged edition by the same house that published this new and, in several respects, most remarkable addition to the literature on shamanic curing. One might hope for sufficient demand for María Sabina so that this work, too, will be republished at a more modest price, ever if it means sacrificing the cassettes or which Wasson recorded the entire chant of one charismatic Mazates curandera.

Reviewing Soma in the April 1971 issue of American Anthropologist Weston La Barre, one of the foremos students of the anthropology and psy chology of religious movements praised Wasson for his meticulous scholarship; the author's willingness he wrote, to pursue the quest for the botanical identity of the mysterious divine Soma plant "through the wide range of linguistics, archeology folklore, philology, ethnobotany plant ecology, human physiology and prehistory constitutes an object lesson to all holistic professional stu dents of man." Indeed it was, o should have been.

In drawing all these diverse field together, Wasson demonstrated tha *Soma*, the previously unidentified psychoactive plant deity whose ine



María Sabina, right, performs the curing ceremony with the help of her daughter.

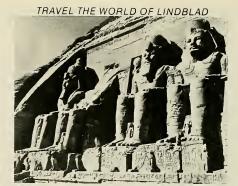




riating juice the Brahman priests of early four millennia ago drank in ites that were the focal point of Vedic eligion, was none other than the acred mushroom of Siberian shananism, the flaming red fly-agaric, *tymanita muscaria*.

The list of Wasson's writings since ne 1950s is extensive, and his contriution to the ethnobotanical and hemical investigation of some of the najor Mexican Indian plant halluinogens, considerable. Take, for exmple, ololiuqui and tlitlitzin, Aztec erms for the psychotropic seeds of vo species of morning glory, Rivea orymbosa and Ipomoea violacea, ie use of which Wasson described in ome detail in the 1960s. In 1941 the ong-standing debate over the botancal identity of ololiuqui was finally ettled with the publication of a definive monograph by Richard E. chultes, now director of Harvard's otanical Museum. This established, nce and for all, the correctness of its xteenth-century identification as a





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morning glory. Mexican scholars had all along accepted this identification, but one American botanist, William E. Safford, steadfastly maintained that the Aztecs and the learned sixteenth-century Spanish physician Francisco Hernandez were wrong and that no Convolvulaceae (the morning glory family) were psychochemically active. The psychedelic properties of morning glory seeds, familiar for centuries to Mexican Indians, were experimentally confirmed by various investigators, but the precise chemicals involved were not to be known until 1960, when Albert Hofmann, the Swiss discoverer of LSD, announced to a startled scientific world that he had isolated lysergic acid amides closely related to LSD from morning glory seeds. It was Wasson who in late 1959 had sent Hofmann morning glory seeds from Mexico in quantities sufficient for proper laboratory analysis.

Hofmann and Wasson had previously been associated in the investigation of the sacred mushrooms of Mexico, and it is of course in this new area—the field of ethnomycologythat Wasson made his major impact. Wasson and his late wife, Valentina P. Wasson (with whom he coauthored Mushrooms, Russia, and History), had-over several decades of devoted research and travels-discovered that when it came to mushrooms, Indo-European peoples, and probably others, could be divided into two distinct camps: "mycophobes," who by and large reject mushrooms as repugnant fungal growths, and "mycophiles," who not only like mushrooms but often carry their fondness for these interesting plant forms to astonishing lengths—even to the point of calling poisonous varieties by endearing

Traveling through Europe and Asia, the Wassons came to recognize that mycophobia and mycophilia could only be explained in culturehistorical terms-in short, that the widely differing attitudes toward mushrooms among different peoples were likely rooted in long-forgotten religious taboos that originated in cults in which the magical powers of sacred mushrooms played a central role. Because of the wide distribution across northern Eurasia of apparently ancient ecstatic rites involving the fly-agaric, especially in Siberian shamanism, and the great body of folklore about the "magic mushroom"

all over Europe, Wasson surmised that Amanita muscaria, long though by many people to be poisonous even deadly, had been employed as a divine hallucinogen in pre-Christian religious cults. From here the path led inevitably to the question of Soma whose identity had puzzled scholars ever since the discovery of Sanskri by Europeans in the eighteenth century, and for which all sorts of more or less unlikely species had been proposed over the years before Wasson came along with Amanita muscaria

Wasson has rightly emphasized one great advantage he had in his wide-ranging inquiries; he and his wife, he wrote in 1972, had been am ateurs, "unencumbered by academic inhibitions, and therefore . . . free to range far and wide, disregarding the frontiers that ordinarily segregate the learned disciplines." True enough but Wasson is, if anything, more con servative, cautious, and meticulous in his scholarship than many who boast of university degrees. Charac teristically, he often refuses to accep as fact any secondary informationwhatever its source-that he canno confirm through personal observa tion, even if it means that others wil be first to publish what he is stil painstakingly trying to authenticate.

Notwithstanding such praise worthy caution, on the question o *Soma* Wasson is not without academic detractors. There are thos who simply will not accept his thesis no matter how many references in th Rig-Veda seem to fit *A. muscaria* bet ter than any other plant.

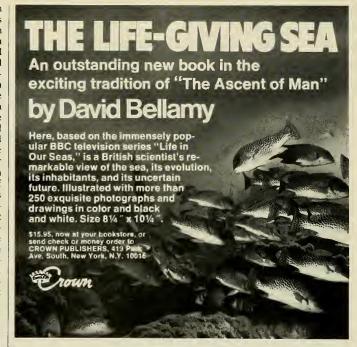
No such controversy is likely to achere to Wasson's latest production, a solid a piece of ethnography as on could wish for. It had its genesis it the early 1950s, when the Wasson began their field research on the rediscovered Mexican mushroom cults whose continued vitality the Indian had carefully concealed for centuric from the outside world in response to the persecutions of the early colonic church.

The heart of the work is the complete rendition, in Mazatec, Spanish and English, of the text of a shamani curing ceremony performed on the night of July 12–13, 1958, by the famous María Sabina in the village of Huautla de Jiménez, in the northerr most part of the state of Oaxaca María Sabina was supported in the ceremony by her daughter María Apolonia, herself a curandera, and lower-level curandero. Aurelio Cau

eras. The title of the book is taken rom velada ("night vigil"), which is what the Mazatec call the session when speaking Spanish. In addition o the text, transcribed and translated y Mazatec specialists George and Florence Cowan, the volume inludes a superb sequence of fifteen plack-and-white photographs of the ession by Allan B. Richardson; a liscussion of the Mazatec language by George Cowan; musicological iotes on the velada by Willard Rhodes, professor emeritus of music t Columbia University and director meritus of the Center for Studies in Ethnomusicology; a melograph of María Sabina's voice by Charles Seeger of the Institute of Ethnomusiology, University of California at os Angeles; and a very useful anaytical index to the transcription of the elada by Wasson himself. The late cobert J. Weitlaner, a pioneer ethographer with Mexico's National nstitute of Anthropology and Hisory, who had been among the first confirm the survival of prelispanic mushroom cults into modrn times, and the late Stephan F. orhegyi, director of the Milwaukee ublic Museum, also contributed thnographic notes to the text.

The volume is linen-bound with a andsome cover design appropriately iken from a hand-woven Mazatec oman's garment known as a huipil. icluded is a boxed set of four casettes of María Sabina singing her veada, in which the curandera, or nore correctly, the divine mushroom peaking through her, finally proounces the judgment that the paent, a boy named Perfeto, will die. he patient, hearing the awful news, oes pale and collapses. (As I have lso observed in Huichol peyote ances, the shaman is able to come ut of the ecstatic state at will; María oes so in response to the sick boy's larm.) After a little while he asks the urandera if what he heard her say is ue. She replies, "Yes, Jesus Christ ays [so]"; Jesus Christ being, as Vasson points out, one with the diine mushroom. Perfeto did indeed ie a few weeks later, just as María ad predicted; Wasson notes that it is npossible to say whether it was his lness (never diagnosed) or her preiction that led to his death.

The identification of the mushroom ith Jesus Christ is typical of the inerpenetration of pre-Hispanic and hristian ideas and concepts in the elada itself and in the syncretistic



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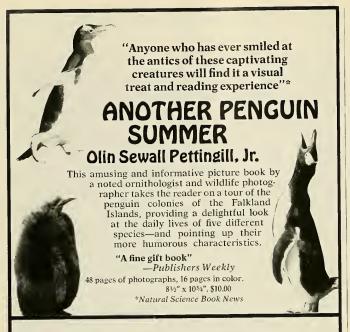
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religion of Mexican Indians in general. The interpenetration, writes Wasson, is complete: the mushrooms, of course, are pagan, but the saints also play an important role in her chant, frequently being mingled with natural phenomena, the whirlpool, the sun, the stars. At the climactic moment when the mushroom reveals through her that the patient is doomed, it becomes totally identified with Jesus Christ, for in contemporary Mazatec belief, the sacred fungi (the species employed in the velada is Psilocybe caerulescens Murrill var. mazatecorum Heim) spring up where Christ has dropped his blood or saliva. This is reminiscent of the belief of the Siberian Koryak that the fly-agaric mushroom originated in the spittle of the great deity Vahivinin, literally meaning Existence. In his musicological analysis of María's singing, Professor Rhodes notes occasional borrowings from Catholic ritual, but most of it is free of European influence and presuma-

bly of pre-Hispanic origin.

Wasson is justifiably excited by another, obviously non-Christian phenomenon in María Sabina's mushroom velada. This is the striking similarity between a number of her passages and a shaman's incantations that a priest named Hernando Ruiz de Alarcón transcribed in Nahuatl, then translated into Spanish a century after the conquest for a manual intended to help the Catholic clergy eradicate the native customs. The incantations are being analyzed by Mexican historian Alfredo López Austin, who has suggested that they were part of a firm and ancient tradition that managed to evade the ecclesiastical persecution. Especially in the style of self-presentation-the reciting of the shaman's credentials to establish why the supernaturals should respond to him or her-there are some remarkable parallels between María Sabina and Ruiz de Alarcón's Nahuatl curers, notwithstanding the passage of more than three centuries and the difference in language and locale. Noting these and other correspondences. Wasson sees López Austin's thesis borne out, suggesting in addition that not only did traditional forms prevail but they may well have transcended the boundaries of Mesoamerica itself. That indeed is more than likely. Many students have noted the sometimes astonishing parallels in shamanistic beliefs and techniques all the

way from the Americas to Eurasia.

Wasson, who once thought them to be entirely independent, is now prepared to consider very ancient ties between the mushroom cults of Mesoamerica and archaic Siberia.

On one point-seemingly minor but actually crucial to an understanding of the interplay of space and time in Mesoamerican Indian thought-I would like to offer an addendum to an issue Wasson raises about the veracity of Ruiz de Alarcón. Noting that the seventeenth-century Nahuatl shaman identifies himself directly with the deity, while the deity only speaks through María Sabina in her incantation, Wasson asks: "Am I wrong in suspecting that the Spanish ecclesiastic suppressed the distinction and made the shaman speak as the deity rather than for the deity? The sacrilege, the impiety, would be so much the more heinous when a brujo asserted that he himself was God. Or perhaps his terrified informants failed to make clear the distinction.'

Ruiz de Alarcón did not distort the text. In an as yet unpublished paper unknown to Wasson when he completed his book, López Austin shows why the Nahuatl shaman in his magical incantations merged himself with the divinity, in this instance Quetzal-

cóatl, the feathered serpent god. The combination of chanted myth and magical plants, López Austin proposed, permitted the shaman to break free from the here and now, as well as from his own personality, and travel to a world in which the action that is being attempted—the cure—is both feasible and more effective. The case involved the setting of a fractured limb. Self-identification with a divinity, who has the power to counteract the evil spirit who caused the fracture and to mend the broken bones, enables the magician to transpose himself and his patient into a moment in time "that by virtue of being of the Creation, and hence critical, abnormal, is also malleable, pliable, subject to easier manipulation than any other." Manipulation, that is, by the divine Quetzalcóatl. That is why the shaman can intone, "I am Quetzalcóatl," and mean it. He has traveled through space and time into another, magical era when everything was possible. And that is very different and mystically much more profound than curing by simple analogy, for example: Quetzalcóatl mended broken bones, I call myself Quetzalcóatl, thus I can mend broken bones.

A close rereading of the mushroom

velada with López Austin's new insights in mind should reveal more of these obviously ancient and probably pan-Mesoamerican space-time concepts. And I agree with Wasson's expressed feeling that if we could compare it with complete shamanic texts from other areas, including Siberia, we would likely find in María's velada remote traces of Siberian and Asiatic shamanism and the shamanism of the early migrants from Asia into the New World. Recurring religious formulas, he observes, are "among the oldest and certainly the most intimate cultural legacies that we inherit from man's past, and especially so when they and timeworn musical chants are inseparably interlocked.'

At the very least, we can agree with him that by opening her house on the night of July 12-13, 1958, María Sabina "unlocked the portals, flung wide the gates, to the arcanum arcanorum of the Mesoamerican Indian's spiritual life." So did Wasson with this exceptional addition to the Native American literature.

Peter T. Furst is professor of anthropology at the State University of New York at Albany.



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Celestial Events

by Thomas D. Nicholson

Sun and Moon During late December and early January, the southerly declination of the sun keeps it quite low in the mid-latitude skies of the Northern Hemisphere, bringing short days, long twilights, and long nights. The earliest sunset takes place about December 8; the shortest day is December 22; perihelion (the earth nearest the sun) is on January 4; and the latest sunrise of the year is about January 5.

In both December and January, the evening moon will appear by the end of the final week. It will wax to full, brightening the sky all night, shortly after mid-month, becoming a morning object thereafter, rising after midnight during the last week. Full moon is on December 18, last-quarter on December 25, new moon on January 1, first-quarter on January 9, and full moon again on January 16.

Stars and Planets Three planets appear on our Star Map this month. Jupiter, outstanding among the dim stars of Pisces, will become visible high in the south at sundown. It will set about midnight or earlier. Not as bright as Jupiter and clearly more yellow or red in color, Mars will be found well to its left, in Taurus. It will form a large triangle with two stars almost as bright and very similar in color—Aldebaran, in Taurus, and Betelguese, in Orion. Over the months ahead, by regularly watching Mars's movement relative to those two stars, you will see it change direction several times. The third planet to appear will be Saturn, rising several hours after sundown along with the twin stars, Pollux and Castor, in Gemini. Saturn will be so close to the stars and so similar in appearance that it will look as though the twins have become triplets this year.

In the morning, there will also be three planets available to greet the dawn, Mars low in the west and setting, Saturn with the twins in the southwest, and Venus, brightest of all, rising in the southeast.

December 15: Mars is at opposition from the sun. It is now visible all night.

December 17: It will be easy to see Mars tonight, moving across the sky close to the full moon.

December 20: Tonight it is Saturn's turn to be near the moon, from several hours past sunset until dawn.

December 22: The sun arrives at the winter solstice at 6:46 A.M., EST, and winter begins in the Northern Hemisphere.

December 23: The Ursid meteor shower (dim and relatively sparse) reaches maximum.

December 25: The moon reaches perigee, nearest earth.

December 26: The star near the moon early this morning is Spica, in Virgo.

December 29: Venus and the moon are together this morning.

January 3: Mars is near the moon tonight.

January 5: Mercury is at its greatest distance to the left (east) of the sun. Although quite low at sundown, it may be seen as an evening star near the southwestern horizon for a few days before and after.

January 8: The moon is at apogee, farthest from earth.

January 9–10: Jupiter will be near the moon on both evenings.

January 13: Mercury begins its retrograde (westerly) motion in passing between earth and sun.

★ Hold the Star Map so the direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 10:20 P.M. on December 15; 9:20 P.M. on December 31; and 8:20 P.M. on January 15; but it can also be used for an hour before and after those times.





Slaves' Holiday

by Robert Dirks

The costumes were bright, the dancing gay, but behind the Christmas revelry of deprived plantation hands in nineteenth-century Jamaica, lurked the threat of murderous rebellion.

On January 1, 1816, Matthew Gregory Lewis disembarked from the Sir Godfrey Webster at Black River, Jamaica, a small port on the island's south coast. Lewis, the author of The Monk, a work widely regarded as a masterpiece of Gothic terror, was making his first visit to the West Indies. It was a visit prompted by a troubled conscience.

Some years earlier. Lewis had inherited two sugar plantations on the island. For a man prominent in London's literary circles and immersed in an intellectual climate strongly antipathetic to slavery, ownership of these properties caused considerable worry. Haunted by the brutal scenes portrayed in abolitionist literature, Lewis's concern about the slaves on his estates finally drove him to book passage for Jamaica.

His initial encounter with island life could not have proved more astonishing. Contrary to his dark imaginings, Black River seemed a colorful and exciting town. Smartly dressed crowds thronged the streets. The town reverberated with music and laughter; here and there, exotically costumed men and women cavorted about, and troops of merry singers and dancers made their way from house to house in noisy processions. Captivated by the spectacle and its high-spirited camaraderie, Lewis continued to watch as the festivities trailed off into a night lit by the glow of countless torches. His journal entry, perhaps a reflection of his own relief, as well as the delusions of long-time residents, tells of being approached again and again by fellow Englishmen with the same question: "Well, sir, what do you think Mr. Wilberforce would think of the state of the Negroes if he could see this scene?"

William Wilberforce, Britain's leading antislavery crusader, undoubtedly would have been as surprised as Lewis by Black River's New-Year revels. But then, the day's events were hardly characteristic of everyday island life. Jamaican New-Year celebrations represented a spectacular climax to the Christmas holidays, a period when plantation laborers put aside their burdens in favor of a few days of riotous merrymaking. Nowhere else in the West Indies were holiday observances so elaborate or so totally given over to the spirit of bacchanal, although from an early date this had been a special time for slaves throughout the British Caribbean. By the latter half of the eighteenth century, every colony celebrated two or three holidays each Christmas. Slaves of all sortsdomestics, craftsmen, and field hands-enjoyed incredible license. Indeed, their behavior constituted such an antithesis to ordinary life that the slaves' Christmas stands as more than a historical curiosity. The event could be called a rite of reversal, a term anthropologists use to describe a ritual event in which everyday patterns are turned topsy-turvy.

No single historical source offers a complete description of the dramatic transformations that overtook plantation communities each Christmas. Accounts of the holiday fetes on Jamaica during the early decades of the nineteenth century offer the best detail, but even these are fragmentary. Only by piecing the Jamaican literature together and comparing it to narratives from other islands can we reconstruct a broad ethnohistorical picture. While this general composite does not do full justice to the variations between islands, at least it captures some of the context and vitality of a nearly forgotten complex of Afro-American expression, particularly the rich tradition that had developed by the end of the slave era.

The slaves' Christmas typically began on December 24. At noon, overseers dismissed their laborers and suspended all efforts to enforce the rules and routines that usually governed plantation operations. On thousands of estates, all work came to a halt. Even the legions of domestics abandoned their posts, leaving masters and mistresses to fend for themselves.

With suspension of the regular routine, plantation life suddenly became animated as slaves rushed to prepare for the festivities ahead. Most hurried to their gardens to gather provisions for holiday feasting. Overseers helped by doling out extra rations of cereals, salted fish, and fresh meat. In addition, they dispensed liberal quantities of rum, enough to sustain the monumental drinking sprees that many slaves regarded as essential to their holiday pleasure. Throughout the afternoon, activity spilled into nearby markets, where some new article of clothing or a few trinkets might be purchased to complete a Christmas outfit. Even common field hands had a few coins to purchase something special on Christmas Eve.

Most preparations were completed by dusk. Ordinarily, night assemblies in the West Indies were closely watched, if not banned outright, but during the holidays, this prohibition was lifted. From early evening, booming drums punctuated the darkness as slaves performed rites over the graves of the dead. Those less devoted to their ancestors gathered at dances—some organized by enterprising women who charged a small

Roaming the streets at Christmas, Actor-boys mimed supplications for food. They were supported by a chorus repeating "koo-koo, koo-koo," an imitation of the rumblings of an empty stomach.

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KOO, KOO, OR ACTOR-BOY.

price for admission. The night's activities typically continued until dawn.

Plantation workers heralded Christmas day by first paying their respects to owners, overseers, and the other principal whites on the estate. A planter's wife on Antigua reported (with obvious annovance) that a band of blacks arrived at her door at four o'clock one Christmas morning and offered their greetings by raucously playing drums and fiddles in the predawn darkness. At the conclusion of their serenade, the musicians shouted in unison: "Good morning to you, massa. Good morning to you, missis. Good morning to you, ladies and gentlemen all." Later, the band returned to collect a small sum in appreciation for their musical salutation.

Not all greetings were extended at such an early hour. During a residence on Saint Vincent, William Young received his visitors at midmorning. The slaves, all "exceedingly well dressed," wished him a merry Christmas and, as two fiddlers struck up a tune, others danced "an excellent minuet." Slaves in Trinidad greeted their masters with long, eloquent speeches full of good wishes. The oratory concluded with songs expressing hope for a profitable sugar crop. Planters usually expressed their appreciation with such gifts as clothing and blankets.

Christmas morning was observed somewhat differently on Jamaica. When slaves paid their call on owners and managers, they arrived in several separate contingents, each composed of individuals with a particular tribal allegiance or belonging to a particular

echelon in the estate hierarchy. After saluting the residents of the great house, each group offered its own dance. Planters reciprocated with presents and then opened the doors of their residences. Inside, slaves were regaled with choice food and drink. Entertainment included music, and masters honored some of their servitors with invitations to dance.

A remarkable scene described by one planter, of an English lady lustily playing the piano while her slaves skipped and pranced about her parlor, provides a revealing glimpse at the sort of uninhibited activities that typified these gambols. Indeed, things often became boisterous, with slaves joining in satirical songs aimed at their hosts or boldly offering free advice concerning plantation affairs. But these advances were taken goodnaturedly, and a degree of decorum generally prevailed. In the evening, the slaves left to dance in their own quarters.

Excitement continued on the day after Christmas as towns and villages on many islands took on the atmosphere of a fair. Throughout the morning, people strolled between gaily decorated booths displaying assortments of foods and fine apparel. In some communities, activities were liable to be interrupted at any moment by drums announcing the arrival of "John Canoe," an entertainer whose antics were a major holiday event.

John Canoes were masked characters impersonated by male slaves. Their Christmas appearance in Jamaica seems to have been a long-standing tradition that may have originated as far back as the seventeenth

century. As portrayed by planter and historian Edward Long in 1774, Jamaican John Canoes wore terrifying masks with boar's tusks protruding from the mouth and oxhorns sprouting from the head. Each carried a wooden sword and was followed about by a group of intoxicated women who offered the masquerader frequent drinks. Accompanied by their attendants, John Canoes roamed entire neighborhoods, stopping at every door to dance and bellow "John Canoe!" Householders customarily honored this menacing visitor with a few small coins.

The custom of John Canoe probably derived from traditional African masquerade, such as the Bambara's kono. There is even a certain similarity in the names. Yet, with regard to the name itself, there has been considerable controversy. Edward Long believed that the designation was a tribute to John Conny, a person supposed to have been an esteemed tribal headman on the Guinea coast in the 1720s; others maintained that the title was linked to the slaves' experience of being transported to the West Indies aboard "house-canoes." I. M. Belisario, whose descriptions and drawings make up the best record of a nineteenth-century Jamaican Christmas, contended that the name was a corruption of the French phrase gens inconnus, a reference to the 'unknown folks'' behind the John Canoe masks. Finally, F. G. Cassidy, a contemporary scholar, believes that the name may derive from a term meaning "sorcerer-man" in the Ewe language of West Africa.

Whatever the origin of the John Canoes, the tradition underwent a series of changes over the years. A number of novel masks made their appearance on Jamaica in 1769, when groups of Africans, including the Ibo and Papaw, introduced their own tribal masks. Later, Matthew Lewis's journal described a new kind of figure, which seems to have replaced the fierce, militant John Canoe: this



I.M Belisario, from the institute of Jemeica collection

Women slaves also took part in Christmas celebrations. Forming "sets," they competed fiercely for superiority in beauty, grace, costume, and song,



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character, a 'Merry-Andrew,' was dressed in a striped doublet and carried a model houseboat on his head. The houseboat itself was filled with puppets representing sailors, soldiers, and slaves. Numerous variations expanded on this theme. The headgear might be highlighted with gilt paper and mirrors and topped with a sparkling umbrella, with the whole creation topped by plumes of feathers.

The John Canoe depicted by Belisario was less elaborately costumed. The white mask seems a curious turn on the old English custom of going from house to house during Christmas week in blackface. The image of a horned beast from Long's. day was replaced by the regimental coat and sash of the British military, but the metamorphosis apparently had no effect in lessening John Canoe's frightful nature.

John Canoes appeared on other islands as well. One particularly distinct version, a character known as Moco Jumbo, existed on Saint Vincent. Impersonators wearing false heads walked about the countryside on stilts, accompanied by a gang of swordsmen whose dance was described as containing a certain aura of menace. Still other John Canoes found their way into Christmas celebrations on Bermuda, in North Carolina (where they were known as John Cunners), and along the Mosquito Coast of Central America.

Koo-Koo, or Actor-boy, was a Christmas character unique to Jamaica. Actor-boys roamed in groups, wearing masks and fantastic headdresses and carrying whips to clear their path. Their escort consisted of a band of fifes and drums. Whenever a party of Actor-boys came across an audience from whom they could expect some coins, they enacted a dramatic performance, usually a scene from Shakespeare's Richard III. Their dramatics always involved portrayals of combat and death. Such theatrics became a part of the Christmas festivities relatively late in the slave era. Earlier renderings were simply pantomimed supplications for food supported by a chorus repeating "koo-koo, koo-koo," an imitation of the rumblings of a hungry belly.

Complementing these male mummeries were parades of women organized into "sets." Sets rose to prominence toward the end of the eighteenth century, at first appearing only at Christmas, but later also enlivening New Year's Day along with the John Canoes and Actor-boys.

The set pageant contained a powerful note of rivalry. In various localities, women divided into two factions: the Reds and the Blues. Every year, the sides vigorously contested for superiority, each attempting to outshine the other in beauty, grace, costume, and song. The main participants in these competitions seem to have been domestic slaves. Called "Set-girls," they took their rivalries very seriously, so much so that at times tensions erupted into a melee between factions.

Within each set, a queen reigned paramount. As a symbol of her authority, she sometimes carried a whip ornamented with ribbons. She was also distinguished by the most stunning costume and a wealth of jewels loaned by her mistress. Various officers and performers attended the queen. Her retinue might include several grand masters to "protect" the set, a king resplendent in a full admiral's uniform, a commodore impersonated by a very stout lady, and numerous singers, fiddlers, drummers, and tambourinists. According to Belisario, the queens in Kingston were accompanied by a Jack-in-the-Green, resembling the character traditionally associated with chimney sweeps during English May Day festivities. The Jack-in-the-Green was covered head to toe with palm fronds, and a huge bow and a number of fluttering flags crowned his leafy costume.

The Set-girls themselves wore exquisite gowns, all of the same hue, red or blue. Outfits varied from one year to the next and were prepared by seamstresses sworn to secrecy, lest members of the rival set discover and better the design. The cost of the Setgirls' dresses and jewelry was not trifling; some women were said to go in rags the whole year in order to save for their holiday raiment. Masters, mistresses, and other wealthy persons frequently took out subscriptions to defray the expense of costumes.

Sets paraded through town or across the countryside, singing from morning until night. In the early evening, they would often station themselves in decorated booths, where they basked in the admiration of the white community. Later they were feted at grand balls in the homes of wealthy gentlemen.

"French sets" were popular in certain areas of Jamaica. The French sets originated with some 20,000 slaves



This photo is the Crystal Skull from prehistoric Mexico and is only one of the features in this magazine about world-wide archeology. Some of the subjects are the pyramids of Egypt, finding the Monitor, pueblo ruins of the American Southwest, Paleo-Indian sites, Roman and Greek archeology, current events in American archeology, the scientific methods used in archeology and opportunities for amateur and professional field work. This coming year will feature a column entitled "The Un-explained". Popular Archaeology, in an easyexplained . ropular Archaeology, in an easy-to-read and well illustrated presentation, brings you the "Mystery and Excitement of the Search and Excavation." Edited by professional archeologists, each issue brings you factual material about the history of our civilization. Subscription is \$9.75 per year, and a second one-year subscription for a gift to a friend is \$7.50.

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who accompanied their masters' flight from Saint Domingue in the late 1790s, when revolution threatened the destruction of the colony's plantations. Members of the French sets remained distinctive by disdaining to dress alike and by professing to find singing and dancing in the streets too vulgar. Their amusements took place exclusively in the homes of planters.

Whether Christmas included two holidays or three, a final feast was the inevitable climax. But within hours after the last notes of music and laughter had subsided, planters were anxious to get on with the work of cutting cane and producing sugar. Brown-skinned domestics met the dawn like so many Cinderellas, divested of their holiday finery and faced with a multitude of familiar chores. And thousands of blacks rose from their beds, no longer carefree celebrants, but menials who made the wheels turn in one of the most regimented and physically demanding modes of production ever devised.

Although the only extended respite from the plantation grind fell at Christmas, it would be a mistake to assume that this annual opportunity for festivity was bestowed on slaves in the seasonal spirit of Christian good will. As a matter of fact, whites looked forward to Christmas with a great deal of dread and apprehension-and with good reason. December brought not only riotous fun; it was also the month in which the slave community was most likely to turn violent. One analysis of plots and rebellions in the British Caribbean revealed that 35 percent took place in (or were planned for) late December, a number far greater than the 8.3 percent one would expect by chance.

Planters were prepared for the danger. Beginning early in the slave era, colonial administrators routinely mobilized the regular army and the militia on Christmas Eve. With whites on the alert and soldiers guarding strategic points throughout the islands, it is puzzling that uprisings continued to be launched during the holidays. Certainly, rebels gained some advantage from the cover of crowds and the freedom of movement, but there was little chance for surprise or hope of success with the armed forces standing by.

Perhaps the high incidence of concerted violence was not just a simple matter of slaves seizing an opportunity to transform revelry into revolution. There is good reason to suspect that rioters and insurgents responded

to conditions that they themselves die not entirely appreciate. The ecolog of the sugar-producing islands mahave exerted environmental pressure that played a significant role in the timing of uprisings.

Several factors combined to creat a pronounced seasonality in the slaves' regimen. Labor on sugar plan tations followed an annual cycle that was divided into two major periods Harvesttime fell during the dry spel that visited the islands from De cember through June. During thes months, slaves cut and milled sugar cane; then manufactured sugar, mo lasses, and rum from the juice. As th rainy season set in, harvesting ende and field preparation and plantin began. Ordinarily, these tasks wer under way by July and continue through November, spanning the so called hungry months, a period whe field gangs regularly experience serious food shortages. Scarcities de veloped as a consequence of season ally minor yields from provisio crops and also because the annua threat of hurricanes kept shipping a a standstill and cut the islands of from outside supply. As a result black populations endured a prolonged period of backbreaking laborate while subsisting on stingy rations c storable grains and starchy tubers.

Without adequate provisions slaves fell victim to an ominous var ety of ills. The symptoms of undernu trition became more acute as th hungry months wore on. Field hand acquired a wasted look and grew ir creasingly sluggish. On some planta tions, famine edema appeared Among the rice-fed laborers of th eastern Caribbean, "Barbados leg (wet beriberi) was commonplace. Ja maican slaves frequently suffere from "coco-bea," descriptions of which suggest the cutaneous symp toms of pellagra. Some individual were driven to dirt-eating, a disorde reckoned lethal throughout the Carib bean. Epidemics of bloody flux als decimated ill-fed gangs, especiall when stores were extremely low These deficiency diseases and the lov resistance to infection brought abou by scanty diets produced alarmin mortality, contributing greatly to th fact that island blacks never consti tuted self-renewing populations unt after emancipation.

The health of field gangs reache its yearly low in November. By mic December, however, a recovery wa under way. Planting was completed

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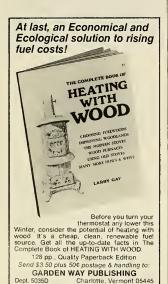
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with only miscellaneous light tasks left before crop time. During this slack period, crops of yams, sweet potatoes, maize, and Guinea corn vielded their first harvests, while the end of the hurricane season brought hundreds of vessels laden with provisions from England and America.

These cargoes, together with the newly available local produce, amounted to a tremendous nutritional increment just before the holidays. The barrels of grain, fish, and fresh meat distributed by planters on December 24 represented a nutritional boost unprecedented at any other time of the year. On Jamaica, for example, a typical Christmas ration for the nineteenth-century slave contained more than 10,000 calories and 1,000 grams of high-quality protein-about ten times the normal daily allowance of rationed calories and twenty times the ordinary allowance of protein. Among human populations, the effects of sudden increases on the heels of sustained want can be explosive.

Festivities marking annual increments in food supply are traditional the world over, and in some cases these are accompanied by an increase in violent aggression. The traditional tribes of southeast Africa offer the best-studied case of such an event. The first fruits of the year would bring an end to a long period of hunger and isolation, and households would join in a variety of ceremonials. But at the same time, fighting and wars were most liable to break out.

Significantly, human experiments have produced similar responses. In studies on human responses to hunger conducted at the University of Minnesota during World War II, conscientious objectors underwent semistarvation. While in an emaciated state, the volunteers were introverted and highly tractable. When the men were recovering, however, they began to exhibit considerable antagonism and became so difficult to manage that the experimenters imagined themselves watching overheated boilers with uncertain safety valves.

Tradition apparently provided the West Indian slave society with fairly reliable safety valves. For people under stress, ceremony often assumes a critical burden, symbolically expressing emotions that may otherwise have no safe behavioral outlet. This is important insofar as relief from hunger seemingly entails a stress response. While the precise neurophysiological mechanisms behind this response are not entirely clear, we do know that once the activities of various higher vertebrates become synchronized to an environment, any rapid change can trigger hyperactivity and a subsequent increase in aggressive behavior. A period of attunement to deprivation followed by sudden relief seems to engender this kind of response in humans.

Whatever the exact mechanisms, the martial dances of the John Canoes, the portrayals of fighting and death by the Actor-boys, the heated quarreling of the Set-girls, the boisterous invasions of white residences. and the satirical barbs tossed at planters all suggest ritualized aggression. Some anthropologists feel that events like these conform to a special class of patterned reversal—the ritual of rebellion. Typically, rituals of rebellion involve the peaceful, sometimes even solemn, enactment of hostility toward established authority.

Endemic political tensions underlie these symbolic expressions, and one is led to wonder what suppression or a heightening of tensions might bring. In this case, the explicit reluctance of West Indian planters to suppress their slaves' Saturnalia, lest more serious or even bloody consequences ensue, suggests an answer. Indeed, after Samuel Martin of Antigua was chopped to death by his slaves on December 27, 1701, for forbidding their holiday, masters seemed to have learned a lesson. They stood by watchfully, but wisely patronized the festivities that allowed their servitors to vent their aggression.

The grim circumstances that surrounded these celebrations should not detract from their culturally ingenious nature. After all, a tradition that is at once indigenous to the New World, yet synthesized entirely from Old World sources; linked to a Christian festival from its inception, but persistently non-Christian in character, must be considered a creative and unique achievement. Today, more than a century after the abolition of slavery in the West Indies, only vestiges of this once lively tradition remain in scattered communities. An attempted revival in Jamaica in the early 1950s failed. The folk expression of bygone days has apparently lost meaning for contemporary islanders. Some regret this. But the loss of a tradition so intimately linked to repression and privation is a small price to pay for human freedom and dignity.



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Additional Reading

Elephants (p. 34)

lain and Oria Douglas-Hamilton, a scientist-photographer team, recently completed 41/2 years of field research on elephants in Tanzania. Their lavishly illustrated popular account, Among the Elephants (New York: Viking Press, 1975, \$4.95), is a good general source on elephant natural history, ecology, and behavior. Two other useful recent books are Elephants and Their Habitats, by R. M. Laws et al. (London: Oxford University Press, 1975), and The Natural History of the African Elephant, by S. K. Sikes (New York: American Elsevier, 1971), although Sikes mistakenly attributes thermoregulation in elephants to their ability to sweat. Laws, a major figure in elephant studies, has also published a review of the literature: "Biology of African Elephants" (Science Progress, Oxford, 1970, vol. 58, pp. 252-262). Scientific studies specifically dealing with elephant thermoregulation are rare. I.O. Buss and A. Wallner's "Body Temperature of the African Elephant" (Journal of Mammalogy, 1965, vol. 46, pp. 104-107) gives one means of taking temperatures: a researcher follows behind the elephant until an opportunity arrives to stick a thermometer into the freshest of elephant droppings. K. S. Schmidt-Nielsen's Desert Animals: Physiological Problems of Heat and Water (New York: Oxford University Press, 1964) provides a general overview of some of the physiological bases of other animals' behavioral adaptations to arid habitats.

Welsh Miners (p. 42)

The 3rd edition of A Short History of Modern Wales: 1485 to the Present Day, by D. Williams (New York: McBride Books, 1962); E. G. Bowen's edited volume, Wales: A Physical, Historical, and Regional Geography (London: Methuen, 1965); and Urban Essays: Studies in the Geography of Wales, by H. Carter and W.K.D. Davies (New York: Humanities Press, 1970), provide divergent perspectives on the rise and decline of the South Wales coal industry. The Williams volume describes the political, religious, economic, and social development of Wales; while the Bowen work includes extensive bibliographies, which should prove particularly useful. Paul Conklin, whose photographs illustrate the article, gained insights into the village of Abertillery from The Rape of the Fair Country and Robe of Honour, by the contemporary novelist Alexander Cordell (Garden City: Doubleday, 1959 and 1960), as well as George Orwell's The Road to Wigan Pier (New York: Harcourt, Brace Jovanovich, 1972). (Continued)

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rmy Ants (p. 60)

The most comprehensive, up-to-date ccount of social behavior in the animal ingdom's largest group is E.O. Wilson's cholarly, yet eminently readable, The nsect Societies, recently reissued as a aperback (Cambridge: Harvard Univerity Press, 1971, \$7.95). It originally cost 20.00. An Introduction to the Behavior f Ants, by J.H. Sudd (New York: St. fartin's Press, 1967), is an inexpensive aperback that presents a semipopular decription of the ant world. Army Ants: A tudy in Social Organization, by T.C. chneirla (San Francisco: W.H. Freenan, 1971), reviews more than thirty ears of field and laboratory work on rmy ants by an eminent American Mueum of Natural History curator.

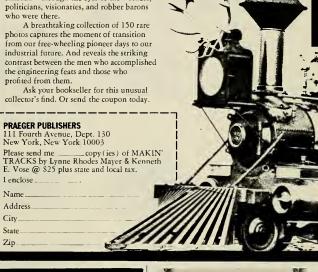
laves' Christmas (p. 82)

Anthropologist Martha W. Beckwith hade four visits to Jamaica "with the urpose of coming into direct contact ith the life and thought of the Negro easant population of the country disicts." More than a half dozen books reulted from those trips, including hristmas Mummings in Jamaica Poughkeepsie: Vassar College Press, 923) and Black Roadways: A Study of amaican Folk Life (Chapel Hill: Univerity of North Carolina Press, 1929). hristmas Mummings in Jamaica, a ecord of holiday ceremonies in a small easant village during the winter of 920-21, is the last description of a vilage celebration before the decline of this aditional activity. 1. Baxter's The Arts f an Island: The Development of the Culire and of the Folk and Creative Arts in amaica, 1494-1962 (Metuchen: Scarerow Press, 1970, \$10.00), a summary of istorical sources, explores Jamaican life a humanistic and artistic vein; Chapter 7 deals with the role of John Canoe in oliday revels. Jamaica Talk: Three lundred Years of the English Language Jamaica, by F.G. Cassidy (New York: t. Martin's Press, 1961), emphasizes the nguistic derivation of characters such as ohn Canoe, as well as the holiday songs nd music of the island. This work is a najor reference to the slave era but also aces the Jamaican language up to resent times. Chapter 9 of Richardson L. Vright's historical popularization, levels in Jamaica: 1682-1838 (New 'ork: Dodd, Mead & Company, 1937), eals specifically with Christmas revels. 'he recently republished Journal of a Vest-India Proprietor: Kept During a esidence in the Island of Jamaica 1815-1817), by the prominent, nineenth-century literary figure Matthew regory Lewis (New York: Negro Uniersities Press, 1969, \$13.50), provides n excellent contemporary account of life n one plantation.

Gordon Beckhorn

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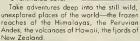
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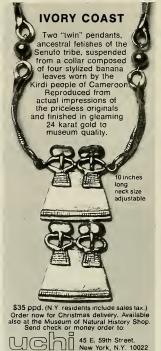
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Announcements

On December 14, a special program, Rainbow Islands Folklore, will be held in the main Auditorium of The American Museum of Natural History, at 2:00 P.M. Talented islanders from the Hispanic Caribbean, Haiti, and Jamaica will present their culture and folklore through their vibrant songs and rhythmical dances.

On December 12, a new exhibition hall, Hall of Mollusks and Mankind, opens on the first floor of the Museum adjacent to the 77th Street Foyer entrance. This new exhibit (the first permanent interdisciplinary exhibition of its kind in the world) will focus on mollusks: their biology, the meaning of shell symmetry, the use of shells and mollusks in scientific studies, and the use of shells as utensils, tools, religious symbols, ornaments, and art objects.

On Monday, December 29 and Tuesday, December 30, there will be special performances of the movie The African Elephant at 11:00 A.M. and 2:00 P.M. in the Museum Auditorium. This remarkable film portrays not only elephant life but also the lives of many other East African animals in their natural surroundings. Tickets, at \$3.00 each, will be available at all entrances on the days of performance.

In the Roosevelt Memorial Hall, second floor of the Museum, The Christmas Tree will sparkle and glisten with 1,500 vividly colored foil origami decorations. The ornaments, all made by volunteers, depict living forms from protozoans to people.

This Exhibit in Preparation continues in Gallery 77, first floor of the Museum. This unusual and informative display reveals the exhibition techniques used to produce the dioramas and exhibits in the Museum. Skilled artists, taxidermists, preparators, and model-makers give periodic live demonstrations.

The World in a Hat continues in the Corner Gallery, fourth floor of the Museum. This delightful 15-minute multimedia presentation shows how hats are used by people all over the world to reflect their position in life. A fairy tale segment of the show tells what can happen when someone wears the wrong hat.

At the Hayden Planetarium of the Museum, The Christmas Sky will open December 2 and run through January 5. This sky show is an annual

December tradition that examines the nature of the Star of the Magi. After a tour of our modern sky, the planetarium projector is used as a time machine to travel back 2,000 years and explore the astonomical possibilities of the star. Shows begin at 2:00 P.M. and 3:00 P.M. during the week, with more frequent showings on weekends. Admission is \$1.75 for adults; \$1.00 for children.



Gardner D. Stout retired on November 24 after seven years as president of The American Museum of Natural History. He was the Museum's seventh president.

The Museum has a long tradition of not pushing its scholars and officers out into the cold when they reach retirement age (Mr. Stout is 72). Accordingly, Mr. Stout has been elected president emeritus and research associate in ornithology. He will continue his dedicated, rigorous, and personal work at the Museum.

A trustee since 1959, Mr. Stout has led the Museum's capital fund drive, which was launched at the Museum's centennial. Almost \$22 million has been attained. Mr. Stout who enjoys understating the importance of his efforts, plans to continue approaching donors with "my hat in my hand" for the final millions of the campaign.

Mr. Stout, who has a strong interest in ornithology, was editor of the critically acclaimed *Shore Birds of North America*, published by Viking Press in 1967. He received honorary doctoral degrees from Pace College in 1969 and from New York University in 1975.





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